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PRINCIPAL INVESTIGATOR: Laurence Steinberg, Ph.D.

CONTRACTING ORGANIZATION: Temple University

Philadelphia, PA 19122, 215-204-1429

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14. ABSTRACT The purpose of our project is to compare decision-making of young males (ages 18-22) acting within groups that are composed in different ways and/or under varying situational circumstances. During this project's funding period, we completed three experiments that allowed us to compare decision-making of young males (ages 18-22) acting within groups in different situational contexts. In the first experiment, we showed that young males are more risky and reward sensitive when making decisions in the presence of three same-age peers relative to when making decisions alone; in the second experiment, we showed that the presence of a slightly older adult significantly <i>attenuates</i> the peer effect, making young males in a peer context less risky and reward sensitive than they are when there is no adult present; lastly, in the third experiment, we showed that the presence of same-aged peers has effects on young adults' decision-making that are comparable to the adverse effects of mental fatigue.					
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I. INTRODUCTION

The broad view guiding the proposed research is that risky decision-making among military work groups (e.g., fireteams) is dependent on the situational conditions and specific age composition of the group members. In the research described herein, we completed three experiments to compare decision-making of young males (18-22 years old) acting in the presence of other young adult team members across different situational circumstances. In the first experiment, we found that when young males are in the presence of three same-age peers, they engage in more risk-taking and are more reward sensitive than when they are alone. In experiment 2, we used the same tasks and procedures that reliably produced a robust peer effect in experiment 1 to show that the inclusion of a single, older team member in the team of 4 significantly attenuated young males' inclination toward immediate rewards and risky decisions. In experiment 3, we found that, contrary to what we expected, high levels of mental fatigue—a common element in combat situations—does not exacerbate the effect of peers on decision-making. Indeed, the presence of same-aged peers has effects on young adult decision making that are comparable to those observed when individuals are fatigued.

II. BODY

The goals of the proposed research were as follows:

1. [Experiment 1] To identify the parameters of decision-making situations that are most likely to lead fireteams composed of four young males (foursomes of 18- to 22-year-olds) to make unnecessarily risky decisions in the presence of peers.
 - a. Using self-report instruments, to identify personality characteristics of individuals who are relatively more susceptible to the peer effect on risky decision-making and those who are relatively less so.
2. [Experiment 2] To determine whether the inclusion of one relatively older individual (25 years or older) within a 4-man team mitigates the peer effect on risky decision-making.
3. [Experiment 3] To determine whether mental fatigue amplifies the impact of peers on young adults' risky-decision-making acting within groups.

In the past 48 months, we have accomplished each of the outlined goals, except 1a (we did not find any personality attributes that were predictive of susceptibility to peer influence).

TABLE 1. MAJOR GOALS OF THIS RESEARCH PROJECT

	Central Aims	Baseline Condition	Experimental Condition	% Completion
Exp. 1	-Explore task dependence of peer effects -Examine predictive value of individual differences	100 Solo Participants <ul style="list-style-type: none"> No mental fatigue 	100 Group Participants <ul style="list-style-type: none"> Adult-absent groups No mental fatigue 	100% Start Date: April 2013 End Date: April 2014
Exp. 2	-Test mitigation of peer effect by presence of older adult group member	100 Group Participants <ul style="list-style-type: none"> Adult-absent groups No mental fatigue 	100 Group Participants <ul style="list-style-type: none"> Adult-present groups No mental fatigue 	100% Start Date: September 2014 End Date: April 2015
Exp. 3	-Demonstrate exacerbation of peer effect under mental fatigue	100 Group Participants <ul style="list-style-type: none"> Adult-absent groups No mental fatigue 	100 Group Participants <ul style="list-style-type: none"> Adult-absent groups Mental fatigue induction 	100% Start Date: September 2015 End Date: April 2016

In experiment 1, we established a reliable experimental battery to demonstrate a robust peer effect in groups of four males between ages 18-22. The test battery included three tasks that reliably showed a peer effect.

We used the Stoplight game to measure risk-taking. Stoplight is a simple computerized driving task in which subjects control the progression of a vehicle along a straight track from the driver's point of view. A timer appears prominently on the screen. Subjects are instructed that their goal is to reach the end of the track as quickly as possible and that a traffic signal will turn yellow as they near each of 32 intersections. At each intersection, they must decide whether to stop the car (by using the space bar), and wait for the light to cycle from yellow to red to green, or go through the intersection. Subjects are informed that if they decide to brake, the car will stop safely, but they will lose time waiting for the light to cycle back to green. They are also told that if they decide to go through the intersection, the car may cross the intersection successfully thus saving time, or the car may crash into a crossing vehicle (an event that is accompanied by squealing tires and a loud crash, as well as the image of a shattered windshield), so that they will lose even more time than if they had decided to brake. Thus, subjects must decide whether to drive through the intersection in order to save time, but chance a collision with another vehicle that will cause them to lose time, or to stop and wait, and willingly lose a smaller amount of time. Risky decisions offered the potential payoff of experiencing no delay, but also the potentially costly consequence of a crash, which added significantly to the delay.

Risk taking (i.e., not braking at a yellow or red light) was encouraged by offering monetary incentives for completing the course in a timely fashion. Specifically, all target subjects were informed that, in addition to their baseline compensation, they could earn a \$15 bonus depending on how they performed on the task. They were told that their performance would be evaluated against a "performance threshold" that was based on how well past subjects had performed on the task, and that they would receive the bonus if they reached the threshold. In actuality, there was no performance threshold, and all subjects received the bonus regardless of their performance. This incentive manipulation was meant to force subjects to pit possible gains against possible losses. We computed a risk-taking score for each subject as the proportion of the 32 intersections at which the brakes were not applied (regardless of whether the subject crashed or crossed through the intersection successfully).

We used a delay-discounting task to measure preference for immediate versus delayed rewards. In the task, subjects were presented with a series of choices between a relatively small, immediate reward and a larger, delayed reward (e.g., "Would you rather have \$200 today or \$1,000 in 1 year?"). They were informed that there was no right or wrong answer and that they should simply choose which of the two (hypothetical) options they preferred. In contrast to the Stoplight game, the delay-discounting task was explicitly introduced as a measure of preference, not performance. The experimenter explicitly stated that subjects' choice had no impact on their final compensation; therefore, we have no reason to believe that the bonus incentive offered for performance on the Stoplight game carried over to influence preference in the delay-discounting task. By removing this contingency, we ensured that the delay-discounting task remained a measure of reward processing outside the context of risk, because the task simply involved a choice between a smaller reward received sooner and a larger reward received later.

The outcome of interest in delay discounting is the extent to which subjects prefer the immediate but less valuable reward over the delayed but more valuable one. In our adaptation of the task, the amount of the delayed reward was held constant at \$1,000. We varied the delay interval across six blocks (1 week, 1 month, 6 months, 1 year, 5 years, and 15 years), presented in a random order. In each block, the starting value of the immediate reward was \$200, \$500, or \$800, randomly determined for each subject. The subject was then asked to choose between the immediate reward and a delayed reward of \$1,000. If the immediate reward was preferred, the

subsequent question presented an immediate reward midway between the prior one and zero (i.e., a lower figure). If the delayed reward was preferred, the subsequent question presented an immediate reward midway between the prior one and \$1,000 (i.e., a higher figure). The subject worked his way through a total of nine ascending or descending choices until his responses converged, and his preferences for the immediate and delayed rewards were equal, at a value reflecting the discounted value of the delayed reward (i.e., the subjective value of the delayed reward if it were offered immediately), which is referred to as the *indifference point*. The task generated six indifference points (one for each delay interval).

For each individual, we computed the average indifference point (across all delay intervals) and the discount rate. The discount rate is an index of the degree to which an individual devalues a reward as a function of the length of delay until receipt, which we computed using the standard equation, $V = A/(1 + kD)$, where V is the subjective value of the delayed reward (i.e., the indifference point), A is the actual amount of the delayed reward, D is the delay interval, and k is the discount rate. Because, as is usually the case, the distribution of k was highly positively skewed in our sample (i.e., skew = 4.398), we employed a natural-log transformation to reduce skew to an acceptable level (−0.279). Lower indifference points and higher log-transformed discount rates indicate a greater orientation toward immediate relative to future reward.

To measure feedback learning, we used a modified version of the Iowa Gambling Task (IGT), in which participants make play or pass decisions on one of the four card decks that are pseudorandomly preselected on each trial. As in the original IGT, two of the decks (C and D) are advantageous, generating modest immediate rewards and relatively small losses, and ultimately resulting in long-term monetary gains over repeated play. The other two decks (A and B) are disadvantageous, generating larger immediate rewards but large losses, and resulting in long-term loss over repeated play. In addition, within each type of deck (advantageous vs. disadvantageous), there is one deck in which the losses are infrequent but relatively large (e.g., \$1,150 and \$200 for the disadvantageous and advantageous decks, respectively), and one in which they are consistent and relatively small (e.g., \$250 and \$25 for the disadvantageous and advantageous decks, respectively).

The payoff schedules for each deck reflected the net outcomes of the original IGT. In the original IGT, but not the version used in this study, every card in each of the decks bore an amount indicating a specific gain (e.g., \$50 or \$100, for good and bad decks, respectively), paired with a varying loss amount (e.g., \$250). In this study, we modified the outcome feedback, such that participants received information on the net gain or loss associated with each card, rather than information on both the gain and the loss separately. For example, if in the original IGT the choice of Deck A produced a card indicating a simultaneous \$100 gain and \$250 loss, the outcome shown in our modified version of the task would be a \$150 loss. This modification removes a heuristic for distinguishing between the good and bad decks, which makes the task more difficult and may encourage greater reliance on emotional cues (rather than explicit memory) to guide behavior. It also removes any advantage due to greater mathematical skill. Finally, this modification also prevents participants from unequally attending to the rewards or punishments, and instead encourages them to focus on the overall gain or loss for a given card.

Each subject starts the task with \$2,000 (of pretend money) and is instructed that his goal is to win as much money as possible. Participants are told that there are good decks and bad decks in the task and that they will earn the most money by learning to play more from the good decks while avoiding the bad ones. On each trial, the computer selects a card from one of the

four decks and participants are given 4 s to decide to either play the card (revealing the monetary win or loss) or pass (in which case no feedback is provided). Subjects played a total of 120 trials, which were divided into six blocks of 20 trials each.

IGT performance was operationalized in two ways: (1) percentage of good plays was calculated as the proportion of times a person decided to play (rather than pass) when presented with advantageous decks on a given block; and (2) percentage of bad plays was calculated as the proportion of times a person decided to play when presented with disadvantageous decks on each task block. As in previous research, the rate of change across the task (i.e., slope) in percentage of good plays served as a measure of reward sensitivity, with more steeply positive slopes indicating increasing attraction to rewarding decks and quicker detection of which decks result in monetary gains over repeated play. The rate of change in percentage of bad plays across the task served as a measure of cost sensitivity, with more steeply negative slopes indicating greater sensitivity to losses produced by the disadvantageous decks.

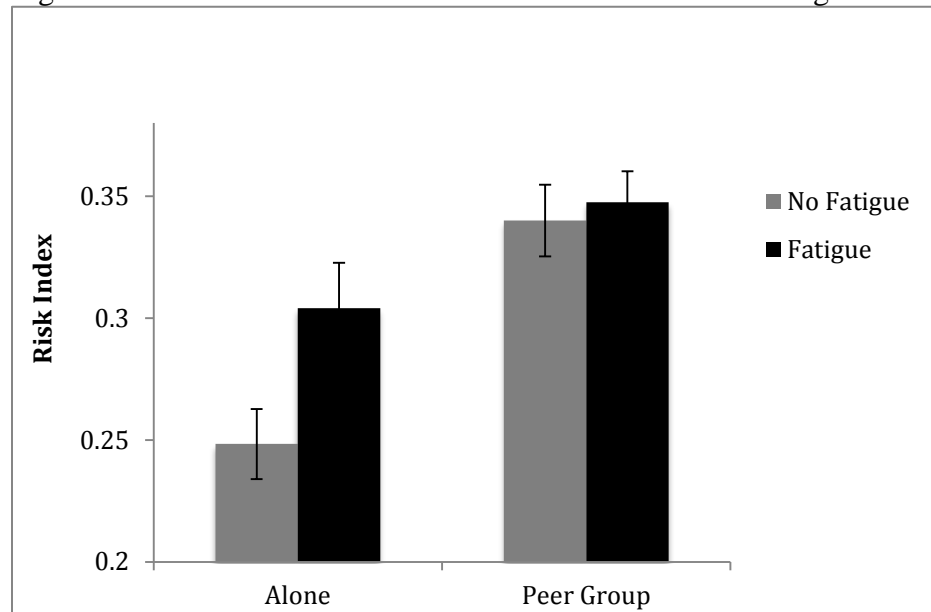
To establish the reliability of this experimental battery in demonstrating a robust peer effect, we recruited and tested 125 “solo” participants and 100 “peer group” participants in experiment 1. Peer group participants were tested in the presence of three other same-age, same-sex peers. Our findings showed a significant peer effect on risky decision-making, reward sensitivity, and feedback learning. Specifically, 18-22 year-old males making decisions in the presence of three peers engaged in more risk taking and were more sensitive to immediate rewards than when making decisions alone. Interestingly, however, we also found that peer presence increases young males’ sensitivity to positive and negative outcomes, such that they learn to approach rewards and avoid punishment much quicker when they are with peers than when they are alone. These results were published in the *Journal for Research on Adolescence* and can be found in the appendix (Silva, Shulman, Chein, & Steinberg, 2015). Peer group data collected in this experiment served as our baseline against which we compared data from subsequent experiments, when either the age mix of the group members (experiment 2) or level of fatigue (experiment 3) was manipulated.

Using the same experimental battery, in experiment 2 we tested 100 young males in an “adult-present” context, where one of the team members was replaced with a slightly older adult. In this experiment, we found that when one of the peers in the foursome is replaced with a 25-30 year-old adult, the presence of same-aged peers has no impact on risk taking or reward sensitivity. That is, the presence of a slightly older adult in the foursome significantly diminishes the previously documented peer effect on decision-making. These results were published in *Psychological Science* and can be found in the appendix (Silva, Chein, & Steinberg, 2016).

In experiment 3, our goal was to examine the joint effects of peer presence and mental fatigue on risk taking, and, more specifically, to investigate whether mental fatigue exacerbates the effect of peers on young male decision-making. In this experiment, we recruited and tested 100 foursomes of 18-22 year-old males in whom we induced mental fatigue. Each subject was fatigued using a behavioral manipulation in which they had to complete a demanding response inhibition task for 20 continuous minutes. After inducing fatigue, each subject in the foursome was brought to the same testing room for testing in a peer-group setting (as done in experiment 1). As in experiment 1, one of the four subjects was randomly selected to complete the experimental battery while the other three peers observed. We tested an additional 56 fatigued subjects in the “solo” condition in order to have an adequate control condition to be able to examine the independent effects of fatigue on decision-making.

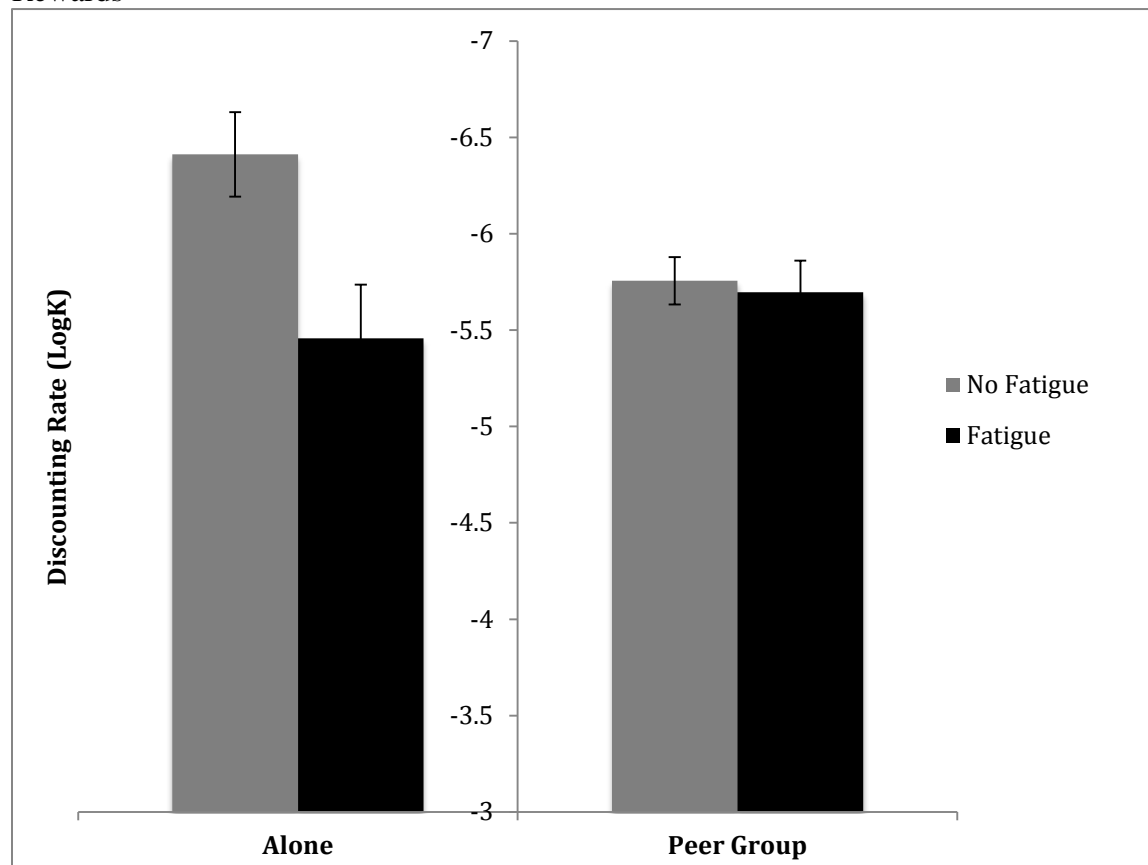
Findings from this experiment showed that, while mental fatigue increases risk taking and reward sensitivity, it does not amplify the effect of peers on decision-making. Specifically, a 2 x 2 analysis of variance was conducted to estimate the main and interactive effects of social context (solo, peer) and fatigue (no, yes) on risk-taking behavior during the Stoplight Task, controlling for age. We found a main effect of social context on risk-taking behavior, $F(1, 348)=18.33$, $p<0.01$, as well as a main effect of fatigue, $F(1, 348)=4.22$, $p<0.05$. Participants took more risks when in the presence of peers or when mentally fatigued. In addition, analyses indicated a marginally significant interaction between social context and fatigue on risky behavior, $F(1, 348)=2.70$, $p=.10$, although in the opposite direction from that hypothesized. As illustrated in Figure 1, fatigue increased risk-taking when subjects were tested alone, $F(1, 341)=5.86$, $p<0.05$, $d=.40$, but no had effect on risky decision-making when subjects were in the presence of peers, $F(1, 341)=.11$, $p>0.05$, $d=.07$. By contrast, the presence of peers had a significant effect on risk taking regardless of whether subjects were fatigued, $F(1, 346)=4.62$, $p<.05$, or non-fatigued, $F(1, 346)=20.83$, $p<.001$.

Figure 1. Interactive Effects of Social Context and Mental Fatigue on Risk-Taking



Moreover, a 2x2 ANOVA indicated a main effect of fatigue on delay discounting, $F(1, 348)=6.67$, $p<.05$, wherein fatigued subjects evinced a stronger preference for immediate rewards than did non-fatigued subjects. Although we found no main effect of social context on discounting, $F(1, 348)=1.13$, $p>.05$, there was a significant interaction between fatigue and social context, $F(1, 348)=4.95$, $p<.05$ (see Figure 2). Fatigued subjects showed a greater preference for immediate rewards when they were tested alone, $F(1, 348)=9.80$, $p<.01$, $d=.45$, but fatigue had no such effects on decision-making when participants were in the presence of peers, $F(1, 341)=.09$, $p>.05$, $d=.04$. Similarly, subjects tended to discount future rewards more steeply in the presence of peers only when subjects were not fatigued, $F(1, 348)=6.37$, $p<.01$, $d=.33$, but peers had no such effects when individuals were already fatigued, $F(1, 348)=.59$, $p=.44$, $d=.13$.

Figure 2. Interactive Effects of Social Context and Mental Fatigue on Preference for Immediate Rewards



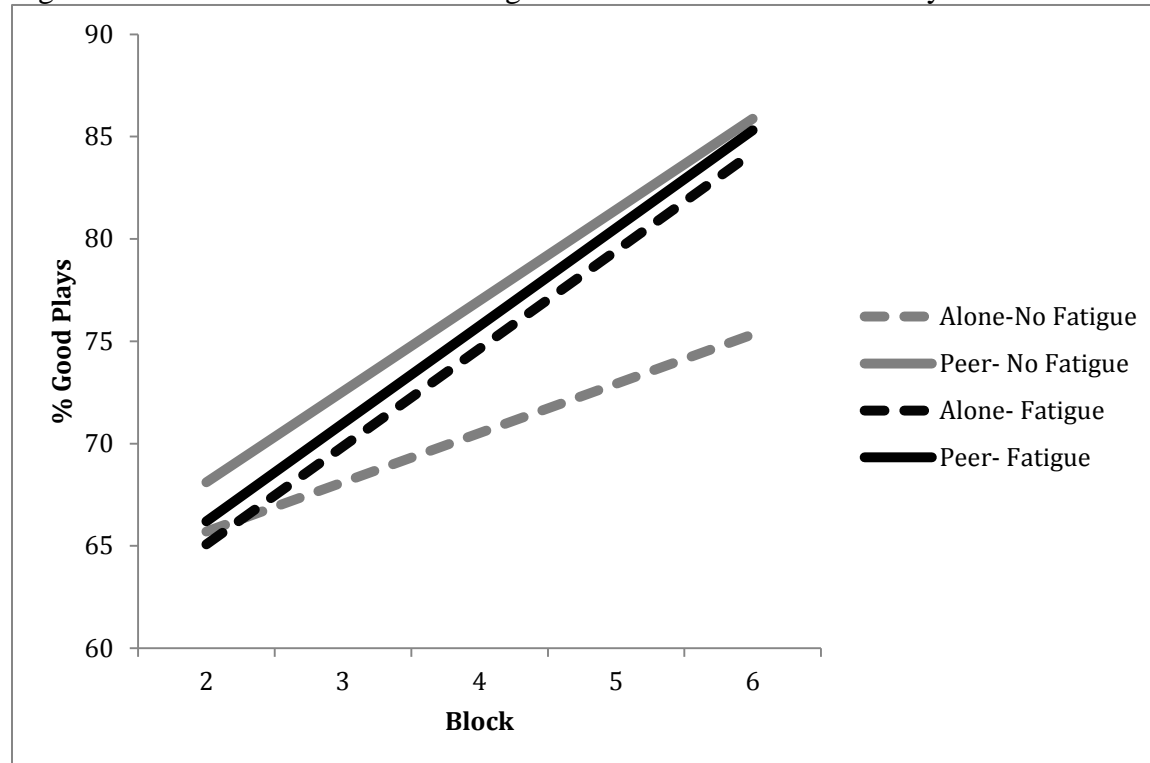
NOTE: Higher discount rates (i.e., values closer to 0) indicate a greater orientation toward immediate relative to future reward.

To investigate feedback learning in the Iowa Gambling Task, we built separate latent growth curve models to estimate the rates at which subjects learned to play on the advantageous decks and learned to refrain from playing on the disadvantageous decks. In these models, time (Blocks 1 through 6) was used as the repeated (within-subject) measure. Time was centered on Block 6 because we were interested in individual differences in performance at the end rather than at the beginning of the task (i.e., to examine the extent to which subjects learned which decks to play or avoid). As a consequence, the estimated intercepts in the models correspond to predicted level of performance (in terms of good plays and bad plays) during the last task block. Social context (solo, peer group), fatigue (no, yes), and their interaction were used as between-subjects factors to predict individual differences in rates of learning from advantageous and disadvantageous decks, and percentage of plays on the last block.

With respect to plays on advantageous decks, social context (alone, peer) and fatigue (no, yes) both had main effects on both the intercept (i.e., percentage of good plays on Block 6) and the slope (i.e., rate at which individuals approached rewarding decks). Specifically, being in the presence of peers or fatigued independently increased the rate at which individuals learned to play on advantageous decks (main effects on slope for social context, $B=2.03$, $SE=.94$, $p<.05$,

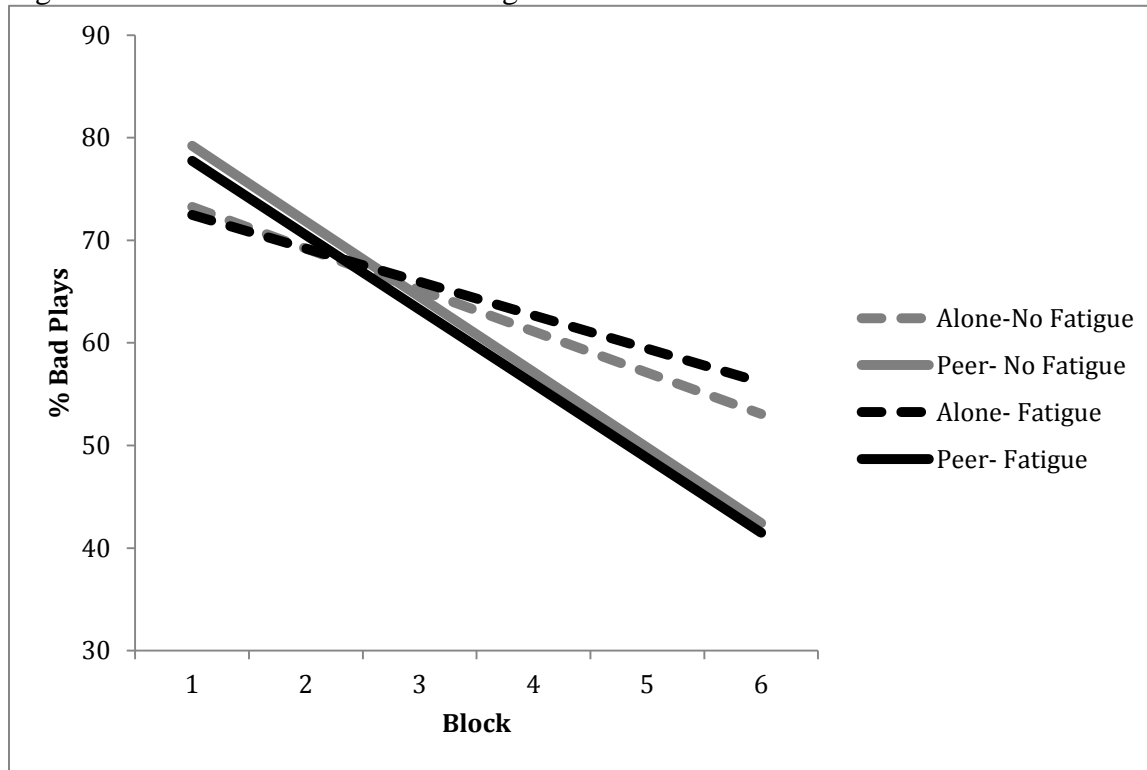
and fatigue, $B=2.38$, $SE=.92$, $p<0.01$), as well as the percentage of good plays during Block 6 (main effects on intercept for social context and fatigue, $B=10.54$, $SE=2.98$, $p<.001$, and $B=8.89$, $SE=2.88$, $p<.01$, respectively).

Figure 3. Social Context x Mental Fatigue Effects on Reward Sensitivity



The interaction between peer presence and mental fatigue was marginally significant in estimating the slope ($B=-2.05$, $SE=1.22$, $p=.09$) and significant in estimating the intercept ($B=-9.45$, $SE=3.86$, $p<.05$). As illustrated in Figure 3, fatigued participants learned to shift behavior toward the advantageous decks at a faster rate than non-fatigued participants only when they completed the task alone ($B=1.94$, $SE=.96$, $p<.05$). In the presence of peers, fatigue had no effect on the rate of learning from rewarding decks ($B=.44$, $SE=.78$, $p=.571$) or overall play rate by the end of the task (Block 6; $B=-.15$, $SE=2.09$, $p=.943$). By the same token, peer presence has a significant effect on rate of learning from rewarding decks when individuals were not fatigued ($B=1.63$, $SE=.84$, $p=.05$ and $B=8.76$, $SE=3.35$, $p<.01$ for the effects on rate of learning and overall play rate in Block 6, respectively). When fatigued, however, the presence of peers had no effect of approach behavior ($B=.22$, $SE=.81$, $p=.79$ and $B=2.05$, $SE=2.13$, $p=.336$, for the effect of peers on rate of change and play rate during Block 6, respectively).

Figure 4. Social Context x Mental Fatigue Effects on Cost Avoidance



With respect to plays on disadvantageous decks (i.e., bad plays), there was a significant main effect of social context on both the percentage of bad plays during Block 6 (i.e., intercept; $B=-10.64$, $SE=5.26$, $p<.05$), and the rate of change in plays from disadvantageous decks throughout the course of the task (i.e., slope; $B=-3.23$, $SE=1.27$, $p<.01$), indicating that participants learned more, and more quickly, when in the presence of peers than when alone (see Figure 4). In contrast, fatigue had no effect on cost avoidance ($B=3.11$, $SE=5.15$, $p=.545$ and $B=.78$, $SE=1.25$, $p=.534$ for the intercept and slope, respectively). The interaction between social context and fatigue was also not significant.

As the above figures illustrate, the impact of peers on young adult decision-making has comparable effects to that of mental fatigue.

III. KEY RESEARCH ACCOMPLISHMENTS

- ❑ **Experiment 1:** Established a reliable experimental battery to demonstrate a robust peer effect in groups of four males between ages 18-22. Recruited and tested of 125 “solo” participants and 100 “peer group” participants. These peer group data provide a baseline comparison against which we compare data from subsequent experiments, when either the age mix of the group members (experiment 2) or level of fatigue (experiment 3) is manipulated.
 - Demonstrated that peer presence increases risk taking, reward sensitivity, and ability to learn from positive and negative feedback.
 - Published experiment 1 findings (Silva, Shulman, Chein, & Steinberg, 2015).
 - Presented findings at two academic conferences, one in 2015 (Association for Psychological Science) and one in 2016 (Society for Research on Adolescence).
- ❑ **Experiment 2:** Recruited and tested of 100 young males in an “adult-present” context, where one of the same-aged team members was replaced with a slightly older adult.
 - Demonstrated that, in the presence of a 25-30 year-old adult, the presence of peers no longer affects risky decision-making or reward sensitivity.
 - Published experiment 2 findings (Silva, Chein, & Steinberg, 2016).
 - Presented findings at the Society for Research on Adolescence convention in April 2016.
- ❑ **Experiment 3:** Used a behavioral manipulation to induce fatigue in order to tests the combined effects of fatigue and peer-presence of young adult decision-making. Recruited and tested a total of 156 fatigued young males, 56 of whom were tested alone (after being fatigued) while the remaining 100 were tested in the presence of three other fatigued peers.
 - Demonstrated the mental fatigue does not exacerbate the effect of peers in risk taking and reward sensitivity.
 - Results from this experiment were presented at the meeting of the Association for Psychological Science (2016) and are being written up for submission to the *Journal of Personality and Social Psychology*.

IV. REPORTABLE OUTCOMES

- ✓ Manuscripts that have resulted from this research and dissemination of results at academic conferences:

1. Silva, K., Shulman, E., Chein, J. & Steinberg, L. (2015). Peers increase adolescents' exploratory behavior and sensitivity to positive and negative feedback. *Journal of Research on Adolescence*. DOI: 10.1111/jora.12219
 - a. Research presented at the Association for Psychological Science (APS) annual convention, New York, NY. May 2015. Lead presenter received a Student Research Award from APS.

ABSTRACT: Adolescents take more risks with peers than when alone. It is not clear how peer presence affects adolescents' risky decision making, however. We used the Iowa Gambling Task (IGT)—a game used to assess decision making involving risk and reward—to examine how peers affect late adolescents' exploration of relevant environmental cues, ability to learn from the outcomes (positive and negative) of that exploration, and ability to integrate feedback to adjust behavior toward optimal long-term outcomes. One hundred and one 18- to 22-year old males (M = 19.8 years) were randomly assigned to play the IGT either alone or observed by peers. Late adolescents tested with observers engaged in more exploratory behavior, learned faster from both positive and negative outcomes, and evinced better task performance than those tested alone.

2. Silva, K., Chein, J., & Steinberg, L. (2016). Adolescent peer groups make more prudent decisions in the presence of a slightly older adult. *Psychological Science*. DOI:10.1177/0956797615620379
 - a. Research presented at the Society for Research on Adolescence annual convention, Baltimore, MD. April 2016.
 - b. Research presented at the Association for Psychological Science Annual Convention, Chicago, IL. May 2016.

ABSTRACT: Adolescents make more reckless decisions when with peers than when alone, which poses a challenge for organizations that place adolescents in situations in which risky and myopic decision making is problematic. We asked whether the effect of peers on adolescents' decision making is mitigated by the presence of a slightly older adult. We examined whether target subjects' risk taking was greater when they were in groups of 4 late-adolescent males (ages 18–22) than when they were in groups that mixed 3 late-adolescent males with 1 slightly older adult (age 25–30); risk taking in both of these conditions was compared with that of adolescents tested alone. We found that adolescents took more risks and expressed stronger preference for immediate rewards when they were grouped with 3 same-age peers than when they were alone. When 1 adolescent was replaced by someone slightly older, however, adolescents'

decision making and reward processing resembled that seen when adolescents were tested alone. Adding a young adult to a work team of adolescents may improve group decision making.

3. Silva, K., Patrianakos, J., Chein, J., & Steinberg, L. (in preparation). Joint effect of peer presence and fatigue on risk taking in late adolescence.
 - a. Research will be submitted to the *Journal of Personality and Social Psychology* for publication.
 - b. Findings on the impact of fatigue on decision making were presented at the 2016 meeting of the Association for Psychological Science.
 - c. Findings on the joint impact of fatigue and peer presence will be submitted for presentation at the 2017 Association for Psychological Science annual convention.

ABSTRACT: Most forms of risk-taking among adolescents and young adults, but not older adults, occur when youth are in groups. Existing research suggests that peer presence may increase youth's tendency to engage in risky decisions, at least in part, by heightening their sensitivity to rewards or to the rewarding aspects of a potentially risky experience. However, there is also some evidence indicating that the magnitude of peer influence effects may be moderated by the availability and engagement of cognitive control resources. Together, existing research suggests that the impact of peers on risky decision-making may be evident, or most pronounced, when reward seeking is high and/or self-regulation is low. In the present study, we ask if the peer effect on adolescent risk taking is stronger when individuals are in a state of cognitive fatigue (i.e., weakened inhibitory control). We found that the presence of same-aged peers has effects on young adults' decision-making that are comparable to the adverse effects of cognitive fatigue, but the joint effect of peers and cognitive fatigue on adolescent decision-making is neither additive nor synergistic. The fact that peer presence and fatigue do not interact but independently elicit similar effects on how adolescents process rewards suggest there may be a ceiling effect on just how much ambient conditions can stimulate reward-related processes.

- ✓ The execution of this project has provided four years of hands-on experience in behavioral research for the graduate student leading the project and for the 12 undergraduate students who helped execute it. All project members who were involved in the data collection and analysis have gained greater proficiency in research methodology and analytical approaches to understanding the data. The project has also provided the opportunity for the lead graduate student to mentor undergraduate students, and for the graduate student and PIs to work closely in the development of publishable products. Lastly, the project has provided the opportunity to participate in three academic conferences. In one of the conferences in which data from this project were presented (at the Association for

Psychological Science annual convention), the lead graduate student on the project was awarded a student research award for her presentation of the findings.

V. CONCLUSION

Although the vast majority of decisions made during combat are made by individuals acting within groups of warfighters (e.g., squads, fireteams), most psychological research on decision-making has been conducted on individuals who are studied when they are alone. Moreover, while there has been some research into the group dynamics of decision-making, these studies are generally focused on how decisions are rendered by the group as a whole, and there are few studies investigating the differential impact of group processes as a function of age. In our prior research, we have found that the mere presence of same-aged peers leads to riskier decision-making among individual late adolescents and young adults - individuals who are similar in age to young soldiers. The research described in this report sought to further characterize this “peer effect” on risk-taking and decision-making by investigating factors and that might increase vulnerability to peer influences on risk-taking, and to identify procedures that could be employed by the Army in order to mitigate the impact of peers on individual warfighters’ decisions about risk. Thus, the research has important implications for how fireteams and other combat work teams are composed, trained, and assigned duties.

In a series of experiments, we examined whether the decision-making of young adult males differs when they are alone in comparison to when they are with three same-aged peers and, if so, whether the effects of peer presence are exacerbated or attenuated by other factors over which commanding officers may have some control. As we have found in previous studies of teenagers, *when young adults aged 18-21 are in the presence of same-aged peers, they make riskier decisions and are relatively more shortsighted than they are when making decisions by themselves.* We also examined whether some individuals, by virtue of their personality (e.g., tendencies toward impulsivity or sensation seeking) are relatively more or less susceptible to this peer effect but found no traits among the many that we examined that appear to make a difference.

Accordingly, officers who are charged with composing, training, and supervising fireteams should be aware that the age mix of the teams they create is likely to have serious consequences for the decision making of the warriors the fireteams comprise. On the positive side, however, we also found that the presence of same-aged peers accelerates the rate at which individuals learn from both positive and negative experiences. Our interpretation of this is that because young adult males in groups are relatively more sensitive to the potential immediate rewards of their decisions (and less sensitive to their longer term consequences) than they are when they are making decisions by themselves, they are more likely to engage in exploratory behavior, which make accelerate learning but may increase risk taking.

More important, perhaps, is our finding that *the deleterious effects of peer presence on young adults’ decision making can be ameliorated merely by substituting one slightly older adult (aged 25-30) for one of the young adults.* That is, we demonstrated that groups composed of three young adult males and one slightly older male made decisions that were significantly less risky and less shortsighted than groups composed entirely of four young adult males. This improvement in the quality of decision making attributable to the presence of a slightly older

adult is not compromised, however, by a decline in the speed at which individuals learn from experience. *Thus, incorporating a slightly older adult into groups of young adult warriors is likely to enhance the quality of soldiers' decision making without diminishing their capacity to learn from experience.*

We also asked whether the deleterious effects of peer presence on young adults' decision making are exacerbated when individuals are mentally fatigued. Surprisingly, the answer to this question is that it is not. Fatigue, as expected, leads individuals to make riskier and more myopic decisions, but only when they are by themselves; individuals in peer groups who are fatigued are no riskier or shortsighted than when they are not fatigued. Our comparison of four groups—fatigued individuals in peer groups, nonfatigued individuals in peer groups, fatigued individuals by themselves, and nonfatigued individuals by themselves—demonstrated that decision making is superior in the last group, relative to the other three. Our interpretation of this finding is that it is both good and bad news. On the plus side, to the extent that grouping young adults with others of the same age is sometimes unavoidable, it is important to know that it is no more dangerous to group young adults together when they are fatigued than when they are rested. On the negative side, however, this result indicates that *being in the presence of same-aged peers compromises young men's decision making to the same extent as mental fatigue.* We suspect that officers are already well aware that their soldiers function better when they are rested than when they are tired. But we believe that officers are not aware that decision making among well-rested young adults may be compromised when they are with people their own age.

This research examined two factors that were expected to moderate the impact of peer presence on young adult decision making—the presence of a slightly older individual, which was found to counter the peer effect (and did), and fatigue, which was expected to amplify it (but did not). These are only two of a myriad of factors that might be studied in future research on the consequences of different types of age-grouping on warriors' decision making. It would be helpful to know, for example, whether the peer effect is exacerbated by factors such as stress or whether it can be attenuated by various types of training designed to mitigate the impact of peers on young adults' cognitive and emotional functioning.

The findings of this research have important implications for the formation of fireteams. To our knowledge, this is the first research to demonstrate that the age mix of a fireteam may have significant effects on the quality of the group's decision making. We recognize that decisions about which warriors to group together for particular combat missions are made for a variety of reasons (e.g., experience, expertise, availability, etc.), but believe that those who constitute and supervise fireteams should add the age mix of the team members to the list of factors they consider when making these decisions. *To the extent that it is possible to combine young adults with slightly older ones, the decision making of the group may be improved and the safety of its soldiers enhanced.*

During the execution of this study, research subjects were each paid a modest honorarium for their participation. No other individuals received payment other than salaries or stipends.

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Conference Presentations

Silva, K., Chein, J., Steinberg, L. (May 2016). Cognitive Fatigue Increases Risk-Taking and Reward Sensitivity without Affecting Ability to learn from Negative Consequences. Association for Psychological Science. Chicago, IL.

Silva, K., Chein, J., Steinberg, L. (April 2016). Cognitive Fatigue Increases Risk-Taking and Reward Sensitivity without Affecting Ability to learn from Negative Consequences. Society for Research on Adolescence. Baltimore, MD.

Meeting Abstract: Adolescents' greater tendency to engage in more risk taking than any other age group is thought to result from a heightened sensitivity to rewards at a time when top-down cognitive control skills are not fully mature. The maturational imbalance between reward-processing and cognitive control systems can be exacerbated by several contextual factors, including cognitive fatigue. Cognitive fatigue often results from insufficient sleep, long work hours, or prolonged periods of sustained attention (such as when in class or studying), all of which are common among late adolescents and young adults. Despite the several sources of mental fatigue, much of the existing research on this topic has focused solely on the link between insufficient sleep and risk-taking behavior among adolescents. While informative, these studies are based on correlational data and none have explicitly investigated whether cognitive fatigue, more generally, increases adolescents' tendency to engage in risky, reward-driven, and short-sighted behavior. In the present study, we examined behavioral differences between fatigued (n=50) and non-fatigued (n=98) late adolescent males who completed a test battery to assess: 1) risk-taking behavior using the Stoplight Task (a driving simulation task), 2) preference for small, immediate vs. large, delayed rewards using a Delay Discounting Task, and 3) sensitivity to reward and punishment using a modified Iowa Gambling Task. Control subjects (i.e., non-fatigued) began the test battery shortly after consent, whereas subjects in the fatigued condition completed two consecutive rounds (lasting approximately 20-minutes) of a cognitive control task, Go-No-Go, before starting the test battery. Results showed that cognitive fatigue exacerbates risk-taking by enhancing

sensitivity to rewards, without affecting sensitivity to punishment. Specifically, relative to controls, fatigued subjects took more risks in the driving simulation task, [$t(147)=-2.35$, $p=0.020$, Cohen's effect size $d=0.41$], and indicated greater preference for immediate, over delayed, rewards in the delay-discounting task [$t(145)=-2.41$, $p=0.020$, Cohen's effect size $d=0.42$]. In the Iowa Gambling Task, fatigued subjects were quicker than controls to learn from rewarding feedback ($b=2.25$, $S.E=.86$ $p=.009$), but there were no group differences in rate of learning from negative feedback ($b=.15$, $S.E=1.30$, $p=.910$). Cognitive fatigue increases adolescents' reward seeking and preference for immediate rewards but does not affect their response to the negative consequences of their actions, which in combination may increase inclinations toward risky behavior. Cognitive fatigue increases adolescents' tendency to engage in risk-taking behavior by exacerbating reward seeking and preference for immediate rewards. However, cognitive fatigue does not affect adolescents' responses to the negative outcomes of their actions, which, in combination with heightened reward sensitivity, may increase inclinations toward risky behavior.

Silva, K., Shulman, E.P., Chein, J., Steinberg, L. (April 2016). Peers increase adolescents' exploratory behavior and sensitivity to positive and negative feedback. Society for Research on Adolescence. Baltimore, MD.

Silva, K., Shulman, E.P., Chein, J., Steinberg, L. (May 2015). Peers increase adolescents' exploratory behavior and sensitivity to positive and negative feedback. Association for Psychological Science. New York, NY.

Meeting Abstract: Adolescents take more risks with peers than when alone. It is not clear how peer presence affects adolescents' risky decision making, however. We used the Iowa Gambling Task (IGT)—a game used to assess decision making involving risk and reward—to examine how peers affect late adolescents' exploration of relevant environmental cues, ability to learn from the outcomes (positive and negative) of that exploration, and ability to integrate feedback to adjust behavior toward optimal long-term outcomes. One hundred and one 18- to 22-year old males ($M = 19.8$ years) were randomly assigned to play the IGT either alone or observed by peers. Late adolescents tested with observers engaged in more exploratory behavior, learned faster from both positive and negative outcomes, and evinced better task performance than those tested alone.

VII. APPENDIX

Peers Increase Late Adolescents' Exploratory Behavior and Sensitivity to Positive and Negative Feedback

Karol Silva
Temple University

Elizabeth P. Shulman
Brock University

Jason Chein
Temple University

Laurence Steinberg
Temple University and King Abdulaziz University

Adolescents take more risks with peers than when alone. It is not clear how peer presence affects adolescents' risky decision making, however. We used the Iowa Gambling Task (IGT)—a game used to assess decision making involving risk and reward—to examine how peers affect late adolescents' exploration of relevant environmental cues, ability to learn from the outcomes (positive and negative) of that exploration, and ability to integrate feedback to adjust behavior toward optimal long-term outcomes. One hundred and one 18- to 22-year old males ($M = 19.8$ years) were randomly assigned to play the IGT either alone or observed by peers. Late adolescents tested with observers engaged in more exploratory behavior, learned faster from both positive and negative outcomes, and evinced better task performance than those tested alone.

Most forms of risky behavior, including activities that jeopardize health and well-being, are more common during adolescence than before or after (Steinberg, 2008). Heightened risk taking during adolescence, typically in the pursuit of rewards, has been observed in several mammalian species, leading some writers to speculate that it is an evolutionarily adaptive behavior thought to encourage separation from family in order to facilitate independence, mating, and, ultimately, reproduction (Spear, 2000). Notably, human adolescents are more likely to take risks when they are with friends than when they are alone (Albert & Steinberg, 2011). This peer effect on risk taking may occur in part because peers heighten late adolescents' sensitivity to potential rewards (Chein, Albert, O'Brien, Uckert, & Steinberg, 2011; Gardner & Steinberg, 2005; Smith, Steinberg, Strang, & Chein, 2015), especially immediate ones (O'Brien, Albert, Chein, & Steinberg, 2011; Weigard, Chein, Albert, Smith, & Steinberg, 2014).

Although adolescents are capable of understanding risk and the possibility of adverse outcomes associated with it (Reyna & Farley, 2006), the extent to which they utilize this information to guide decision making when they are with peers

remains unclear. Although behavioral and neural data generally confirm that peers increase late adolescents' sensitivity to the anticipation and receipt of reward, less is known about the influence of peers on late adolescents' sensitivity to negative outcomes. In one relevant study, adolescents played a "Wheel of Fortune" gambling task, either alone or while believing that they were being observed by peers. Each trial involved gambling on a wheel that graphically displayed explicit information about the probabilities of winning and losing (Smith, Chein, & Steinberg, 2014). Adolescents gambled more when they thought they were being observed than when they were alone, and especially so when they were given information indicating that the probability of losing was greater than that of winning. Thus, peers may motivate adolescents to pursue opportunities for reward, even when the chances of positive outcomes are known to be slim.

Although informative, the findings from this gambling study are limited in at least two ways. First, the experimental paradigm always coupled information about the potential for loss with that about the potential for gain on any given trial—thus, it could not be determined whether the peer effect on risk taking arose because peers increased participants' sensitivity to potential rewards or because peers diminished their sensitivity to potential losses.

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Requests for reprints should be sent to Karol Silva, Department of Psychology, Temple University, Philadelphia, PA 19122. E-mail: karol.silva@temple.edu

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Second, because every trial represented an independent probabilistic event, there was no reason for the participants to use feedback about the outcomes to inform subsequent decision behavior.

Exploring whether peer contexts influence late adolescents' ability to learn from the outcomes of their decisions is important. Because risk taking is relatively more likely to occur with peers, the rewards and consequences of risky choices are also more likely to be experienced in the presence of others. Peers may not only increase adolescents' reward seeking, but also may influence the extent to which positive and negative outcomes are incorporated into learned representations that inform subsequent decision making. To our knowledge, only one study has examined adolescents' sensitivity to negative feedback as a function of social context (Segalowitz et al., 2012), showing weaker engagement of the medial prefrontal cortex (mPFC) in response to loss when adolescents were in the presence of peers than when alone. In a related study, adolescents exhibited greater activation of the ventral striatum (a reward-processing region) when they were with peers than when they were alone (Smith et al., 2014).

Although one might conclude from these neuroimaging studies that peers increase adolescents' sensitivity to rewards and decrease sensitivity to costs, and that this contributes to increases in risk taking in the presence of peers, there were no behavioral differences across the alone versus peer contexts in either study. These findings indicate is that adolescents respond differently, at a *neural* level, to positive and negative feedback when they are in social contexts than when they are alone. We do not know whether subsequent decision making changes differentially as a result of the influence of peers on the way rewards and costs are processed.

In the current study, we extend these earlier studies by examining how peers affect late adolescents' decision making in a task in which optimal performance depends on exploring different options early on and learning from positive and negative feedback. We focus on late adolescents (ages 18–22) because there is considerable evidence that the prevalence of certain real-life, high-stakes risk behaviors (e.g., binge drinking, substance use, reckless driving, and unprotected sex) is highest among 18- to 22-year olds (Shulman & Cauffman, 2014; Willoughby, Good, Adachi, Hamza, & Tavernier, 2014). Moreover, previous studies confirm that decision making among 18- to 22-year olds is significantly influenced by social context (Albert & Steinberg, 2011; Gardner & Steinberg, 2005; Mona-

han, Steinberg, & Cauffman, 2009). Although individuals in this age range are adults by legal standards, developmental evidence suggests that they are psychologically less mature than adults aged 25 and older (e.g., Steinberg et al., 2008). At the same time, these late adolescents are subject to much less "adult" supervision than younger adolescents and often reside in situations in which they are in close contact with peers (in college, or in the military), which may contribute to their higher rates of many risky behaviors, despite their relatively greater maturity. The combination of these factors—psychological immaturity, peer-rich environments, and adult freedoms—makes late adolescents an important group in which to investigate risky decision making and the influence of peers. Importantly, the current study is part of a broader program of research, funded by the U.S. Army, designed to inform military decisions about how best to group soldiers into combat teams. Accordingly, the sample is limited to late adolescent males, who disproportionately comprise squads sent into battle.

We use a modified version of the Iowa Gambling Task (IGT; Bechara, Damasio, Damasio, & Anderson, 1994) to investigate how the presence of peers affects late adolescents' responses to both positive and negative feedback, as well as their ability to integrate experiences of loss and reward to optimize subsequent performance. The IGT is a widely used measure of affective decision making, which is thought to influence risk behaviors. In the version of the IGT used in this study, participants make play or pass decisions in response to one of four decks (A, B, C, or D) that is pseudorandomly preselected on each trial. As in the original IGT, two of the decks are good and generate long-term gain, while the other two are bad and generate long-term loss. The modified version of the task allowed us to separately quantify the rates at which participants learn to play more from the good decks—an indication of sensitivity to rewarding feedback—and learn to stop playing from the bad decks—an indication of sensitivity to punishing feedback (Cauffman et al., 2010). Moreover, the task allowed us to examine late adolescents' active exploration (via decisions to play rather than pass) of all decks throughout the task. In the study, we investigate whether peer presence affects late adolescent males' (1) tendency to explore relevant environmental cues, (2) ability to learn from the outcomes of that exploration, and (3) ability to integrate positive or negative feedback to adjust behavior toward optimal outcomes.

Although decision making during the IGT is not truly risky—participants are playing with pretend money—the affective and cognitive processes involved in the task are closely related to those involved in real-life risky decision making. The task was initially developed to characterize deficits in decision making in adults with lesions of the mPFC, a brain region implicated in decisions involving the pursuit of reward. People with mPFC lesions perform poorly on the IGT; they persist in pursuing a course that yields large immediate rewards despite suffering larger long-term losses (Bechara, Tranel, & Damasio, 2000). In addition to adults with mPFC damage, people who actually engage in a good deal of risky behavior in life, such as gamblers and substance users, also perform worse on the IGT than other adults (Bechara et al., 1994; Mazas, Finn, & Steinmetz, 2000; Monterosso, Ehrman, Napier, O'Brien, & Childress, 2001; Petry, 2001).

HYPOTHESES

We hypothesized that late adolescent males completing the IGT in a peer group would engage in more exploratory behavior and learn to play from the good decks at a faster rate than those completing the task alone. Because less is known about how peer presence affects late adolescents' sensitivity to punishment, we did not have a strong hypothesis about how peer presence would affect the rate at which participants learned to avoid choices that lead to loss. Regarding the extent to which individuals would integrate experience with reward and loss, we hypothesized that greater reward sensitivity among participants in the peer group would contribute to faster improvements in overall task performance (i.e., net score) compared to participants completing the task alone.

METHOD

Participants

Late adolescent males, ranging from 18- to 22-year-olds, were recruited from local colleges and the general community in a large northeastern U.S. city. Participants were also recruited through the subject pool of the home institution's introductory psychology course. In two prior studies of peer influences on late adolescents' decision making (Gardner & Steinberg, 2005; O'Brien et al., 2011), we compared groups of approximately 50 late adolescents tested alone with 50 tested while observed

by peers and found significant group differences with effect sizes of $d = .47$ and $d = .40$, respectively. Although the two prior studies used tasks other than the IGT (a video driving game and a delay discounting task, respectively) and involved two peer observers (rather than three, as is the case in this study), we based our decision in this study to compare two groups of 50 participants each on this prior research. (With an expected effect size of .40, a total sample of 100 provides more than adequate power (.99) to detect a significant effect at $p < .05$.) Analysis for the current study is based on a sample of 101 subjects who completed the IGT either alone ($n = 50$) or in a peer group (i.e., with three late adolescent male peer observers; $n = 51$). Sample recruitment was halted once a predetermined minimum of 50 subjects per experimental group were tested.

Procedure

Manipulation of social context. Flyers advertising a study of decision making invited males between the ages of 18 and 22 to call our research office to learn more about participating in the research. Each caller was told that the study could accommodate up to five people at a time and was asked whether he had any friends (other males between 18 and 22) who might be interested in participating. If a participant referred a friend to the study, our research team communicated directly with that individual to confirm his eligibility. Five participants, some of whom were friends and some strangers, were independently scheduled to participate at a set time, but none was informed that he might participate as a member of a group.

When participants arrived in the laboratory, four of them were randomly assigned to the peer condition and one was randomly assigned to participate alone. Participants in each condition were escorted to separate rooms and instructed about the study. In the peer condition, one participant was randomly selected to take the test battery, which included several tasks, including the IGT, while the other three observed. (Only findings from the IGT are presented in this article.) Study compensation for the player and the observers was \$35 per person (or 2.5 research credits for those in the subject pool). In addition to this baseline compensation, all participants were informed that they could win a \$15 bonus contingent on the performance of the person completing the task. All participants in the alone condition received the same information regarding compensation. Similar to previous studies,

this strategy was used to increase motivation to perform well (Cauffman et al., 2010). In reality, all participants received both the baseline and bonus compensation.

After verbal consent and random selection of a target participant, all subjects in the peer condition were left in the room for approximately 10 min to permit the group to interact naturally. Within peer groups, 37% ($n = 19$) of the target participants did not know anyone else in the group, while the rest knew at least one person. IGT performance among peer group participants did not differ as a function of how many peers they knew prior to the study. All procedures were approved by the university's institutional review board as well as that of the U.S. Army (the funding agency).

Measures

Demographics. Participants reported their age, race/ethnicity, and education. Educational attainment was used as a proxy for socioeconomic status. Participants in each condition (alone, peer group) did not differ on any demographic variables (Table 1). Ninety-one percent of subjects were current college students. The mean age for the sample was 19.8 years ($SD = 1.25$). Sixty-seven percent of the sample was White, 12% Black/African American, 15% Asian/Pacific Islander, 4% Latino, and 2% other/mixed race.

Modified Iowa Gambling Task. As previously mentioned, we used a modified version of the task, in which participants make play or pass decisions

on one of the four decks that are pseudorandomly preselected on each trial. As in the original IGT, two of the decks (C and D) are advantageous, generating modest immediate rewards and relatively small losses, and ultimately resulting in long-term monetary gains over repeated play. The other two decks (A and B) are disadvantageous, generating larger immediate rewards but large losses, and resulting in long-term loss over repeated play. In addition, within each type of deck (advantageous vs. disadvantageous), there is one deck in which the losses are infrequent but relatively large (e.g., $-\$1,150$ and $-\$200$ for the disadvantageous and advantageous decks, respectively), and one in which they are consistent and relatively small (e.g., $-\$250$ and $-\$25$ for the disadvantageous and advantageous decks, respectively); see Cauffman et al. (2010) for a complete description of the deck characteristics.

The payoff schedules for each deck reflected the net outcomes of the original IGT. In the original IGT, but not the version used in this study, every card in each of the decks bore an amount indicating a specific gain (e.g., $\$50$ or $\$100$, for good and bad decks, respectively), paired with a varying loss amount (e.g., $-\$250$). In this study, we modified the outcome feedback, such that participants received information on the *net* gain or loss associated with each card, rather than information on both the gain and the loss separately (Bechara et al., 1994). For example, if in the original IGT the choice of Deck A produced a card indicating a simultaneous $\$100$ gain and $\$250$ loss, the outcome shown in our modified version of the task would be a $\$150$ loss. This modification removes a heuristic for distinguishing between the good and bad decks, which makes the task more difficult and may encourage greater reliance on emotional cues (rather than explicit memory) to guide behavior. It also removes any advantage due to greater mathematical skill. Finally, this modification also prevents participants from unequally attending to the rewards or punishments, and instead encourages them to focus on the overall gain or loss for a given card.

Each subject starts the task with $\$2,000$ (of pretend money) and is instructed that his goal is to win as much money as possible. Participants are told that there are good decks and bad decks in the task and that they will earn the most money by learning to play more from the good decks while avoiding the bad ones. On each trial, the computer selects a card from one of the four decks and participants are given 4 s to decide to either *play* the

TABLE 1
Demographic Characteristics of the Study Sample by Social Condition

	Social Condition	
	Alone $n = 50$	Peer $n = 51$
Age, M (SD)	19.67 (1.29)	19.94 (1.20)
Race/Ethnicity, %		
White	64.7	70.0
African American	15.7	8.0
Asian	11.8	18.0
Hispanic	3.9	4.0
Other	3.9	0
Socioeconomic status, M (SD) ^a	12.94 (0.24)	12.94 (0.31)

^aEducational attainment was used as a proxy for socioeconomic status, where 13 = *some college* (including current college students).

card (revealing the monetary win or loss) or *pass* (in which case no feedback is provided). Subjects played a total of 120 trials, which were divided into six blocks of 20 trials each.

Iowa Gambling Task performance was operationalized in three ways: (1) percentage of good plays was calculated as the proportion of times a person decided to play (rather than pass) when presented with advantageous decks on a given block; (2) percentage of bad plays was calculated as the proportion of times a person decided to play when presented with disadvantageous decks on each task block; (3) net score was calculated as the difference between percentage of good and bad plays, with the latter being subtracted from the former.

Statistical Analysis

Latent linear growth models were fitted using the maximum likelihood estimation method in Mplus (version 7.0; Muthén & Muthén, 2012) to examine the rates at which participants (1) played, rather than passed, summed across all decks; (2) learned to play from the good decks; (3) learned to avoid the bad decks; and (4) integrated reward and loss experience to optimize net score, as well as (5) to determine whether the presence of peers affected these rates. Time (Blocks 1 through 6) was used as the repeated measure to determine the extent to which participants changed their behavior over the course of the task. Social context (alone, peer group) was specified as a between-subjects variable to explain variation in rates of change for percentage of plays (rather than passes), plays from advantageous decks, plays from disadvantageous decks, and net score.

We conceptualized playing, rather than passing, as an index of exploratory behavior, especially during the early blocks of the task, when participants have not yet learned which decks are good and which are bad. As in Cauffman et al. (2010), the rate of change across the task (i.e., slope) in percentage of good plays served as a measure of reward sensitivity, with more steeply positive slopes indicating increasing attraction to rewarding decks and quicker detection of which decks result in monetary gains over repeated play. The rate of change in percentage of bad plays across the task served as a measure of cost sensitivity, with more steeply negative slopes indicating greater sensitivity to losses produced by the disadvantageous decks. Net score was conceptualized as a measure of overall IGT performance that integrates sensitivity to gains and losses, with steeper positive slopes

indicating faster improvements in task performance.

RESULTS

Exploratory Behavior

We first examined participants' overall tendency to play (rather than pass) during each task block, summing across deck types. A repeated measures analysis of variance was conducted with social context as a between-subjects variable and time as a within-subject variable. There was a main effect of time on overall decisions to play, $F(5, 495) = 11.36$, $p < .001$; as the task progressed, the percentage of decisions to play (rather than pass) decreased, with a linear trend, $F(1, 99) = 20.71$, $p < .001$. There was no main effect of social context, $F(1, 99) = 2.68$, $p > .05$. The interaction between social context and time was marginally significant, $F(1, 99) = 3.84$, $p = .053$. We conducted independent samples t -tests to assess the influence of social context on decisions to play at each block. Overall percentage of decisions to play (rather than pass) was significantly greater in the peer condition during Blocks 1 and 2, $t(99) = -2.41$, $p < .05$ and $t(99) = -2.30$, $p < .05$, respectively (Figure 1).

Learning From Experience

Because we were interested in individual differences in performance at the end rather than at the beginning of the task, time was centered on Block 6 in the initial latent linear growth model. As a consequence, the estimated intercepts in the models correspond to predicted level of performance (in terms of good plays, bad plays, and net score) during the last task block.

Reward sensitivity. With respect to plays from good decks, the model indicated that social context

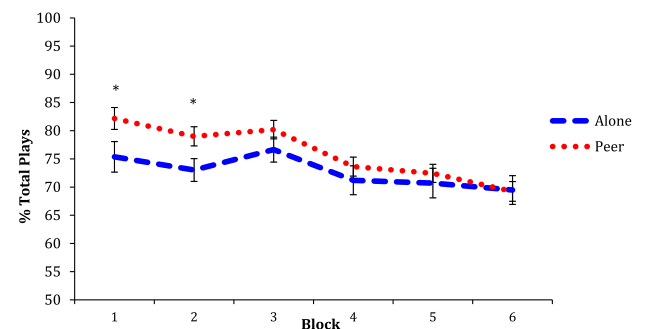


FIGURE 1 Total percentage of plays across time by social condition. * $p < .05$.

had a significant effect on the intercept ($\beta = 9.97$, $SE = 3.32$, $p < .01$); at Block 6, participants in the peer condition made a greater percentage of good plays compared to those in the alone condition. The average slope for both groups combined was positive and marginally significant ($\beta = 1.14$, $SE = 0.59$, $p = .05$), indicating that participants learned to increase their percentage of plays from good decks over time. The rate of learning to play from rewarding decks did not differ by social context, however ($\beta = 0.64$, $SE = 0.83$, $p = .437$).

Because, as noted above, individuals in the peer condition were playing at an especially high rate from the beginning of the task, we further sought to examine whether there was a potential ceiling effect with respect to sensitivity to rewarding decks for participants in the peer condition. Accordingly, we reran the model with the intercept set at Block 1 and found that participants in the peer group were indeed more likely than solo participants to play from advantageous decks in the first task block ($\beta = 6.77$, $SE = 3.38$, $p < .05$). Moreover, this model also revealed a negative and significant correlation between the initial percentage of good plays and rate of change. Thus, the heightened inclination to play from the advantageous cards during Block 1 may have created a ceiling effect for peer group participants, potentially limiting the rate of learning these participants could demonstrate by increasingly playing from rewarding decks as the task progressed.

To address this limitation, we reran the model to estimate the rate of change in advantageous plays from Block 2 through Block 6, controlling for the percentage of good plays on Block 1. Doing so improved overall model fit, and showed that, with initial play rate held constant, participants in the peer condition learned to shift behavior toward the advantageous decks at a faster rate than participants completing the task alone ($\beta = 1.69$, $SE = 2.91$, $p < .05$; Figure 2). The percentage of good plays during Block 1 had an independent effect on the reward-learning slope, indicating that making more good plays at the beginning of the task reduced the rate of learning from advantageous decks ($\beta = -0.07$, $SE = 0.02$, $p < .001$). There was no significant interaction between social context and good plays during Block 1 in the prediction of rate of learning.

Cost sensitivity. Next, we estimated the rates at which participants learned to avoid the bad decks. Being in a peer group was associated with a lower percentage of bad plays during Block 6

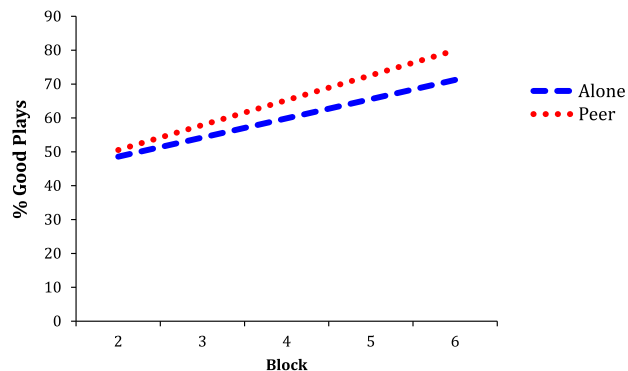


FIGURE 2 Percentage of plays from good decks across time by social condition.

Note. Results control for percentage of plays from good decks during Block 1.

($\beta = -10.80$, $SE = 5.21$, $p < .05$). Social context also had a significant effect on the slope, ($\beta = -3.39$, $SE = 1.23$, $p < .01$), with peer group participants quicker to respond to experiences of loss and reducing their percentage of plays from disadvantageous decks at a faster rate than solo participants (Figure 3).

To examine whether social context had a significant effect on the initial percentage of plays from the disadvantageous decks, we reran the model with the intercept set at Block 1, as we did in our analysis of plays from good decks. The model showed that during the initial task block participants in the peer groups also made a greater percentage of bad plays than participants who were alone ($\beta = 6.26$, $SE = 2.67$, $p < .05$), consistent with the higher overall level of exploratory behavior evinced by participants in the peer condition. However, the overall correlation between intercept and slope, across both social contexts, was nonsignificant, meaning that participants' initial level of attraction to the disadvantageous decks (at the start

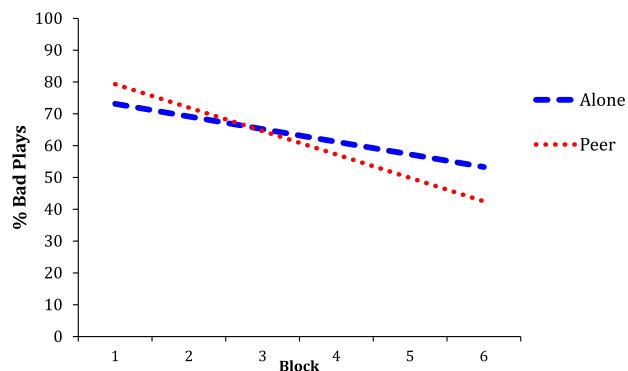


FIGURE 3 Percentage of plays from bad decks across time by social condition.

of the game) was unrelated to the rate at which they adjusted their choices in response to negative feedback over the course of the task.

Net score. Finally, overall IGT performance was examined in terms of participants' net score, which is a measure of performance that integrates sensitivity to gains and losses. For this measure, the intercept reflects the overall performance during Block 1, whereas the slope reflects the rate of improvement in overall performance over the course of the task. The model indicated a positive and significant rate of change in net score ($\beta = 5.96$, $SE = 1.00$, $p < .001$), indicating that all participants improved performance as the task progressed. However, social context had a significant effect on the rate of change ($\beta = 3.67$, $SE = 1.39$, $p < .01$), with participants in peer groups evincing faster rates of improvement in task performance over time (Figure 4). As a consequence, by the end of the task, participants in the peer condition had a higher net score than those in the alone condition ($\beta = 20.53$, $SE = 6.29$, $p < .001$).

Results of the relevant statistical analyses are summarized in Table 2.

DISCUSSION

If some level of risk taking in adolescence is inevitable, as has been argued (e.g., Steinberg, 2008), it is presumably through a process of exploration and learning, via trial and error, that late adolescents are able to eventually shift their behavior toward more prudent choices. The ability to learn from the consequences of past actions is particularly vital for young people, who, in search of novelty and opportunities for reward, often find themselves in new and unpredictable situations, often in group settings. The present study shows

that the presence of peers increases the extent to which late adolescents learn from both positive and negative experience.

Prior behavioral and neuroimaging studies have indicated that the presence of peers increases adolescents' sensitivity to the potential rewards of risky decisions (Chein et al., 2011; Gardner & Steinberg, 2005; Smith, Chein, & Steinberg, 2014; Smith, Steinberg, et al., 2015). The current study was designed to extend this previous research by examining whether the presence of peers specifically affects late adolescents' sensitivity to rewards or whether it enhances late adolescents' sensitivity to feedback more generally (both rewards and punishments). We also aimed to investigate whether social context affects the rate at which late adolescents learn to integrate experiences of reward and loss to guide decision making.

The modified version of the IGT employed in the present study afforded us the opportunity to examine exploratory behavior, by seeing how often participants sought to obtain information about the potential rewards and costs of alternative choices, by choosing to play rather than pass when given the opportunity to draw a card. Being in a peer group was associated with late adolescents' greater tendency to explore the environment, such that they made decisions to play much more frequently than solo participants during the initial blocks of the task, when they lacked information about each deck's payoff schedule. Participants in peer groups were not only more inclined than solo participants to explore the opportunities before them, but were also more responsive to feedback, even in the earliest stages of the task. It is important that the presence of peers increased both the rate at which participants shifted behavior toward making more plays from advantageous decks and the rate at which they came to avoid the disadvantageous ones. Thus, when in a peer group, late adolescents are quicker to learn which choices lead to rewards and which ones have costs. Notably, optimal decision making in the IGT requires individuals to rely on emotional cues (Bechara, Tranel, Damasio, & Damasio, 1996). Also, subjects have been found to display a preference for good decks over bad decks before they are consciously aware of which decks are good or bad (Bechara, Damasio, Tranel, & Damasio, 1997). The fact that, in our study, subjects in the peer condition performed better on the IGT therefore suggests that peer presence can affect decision making processes of which the subject is not even aware.

Our decision to make the peer observers' compensation contingent on the target adolescent's performance stemmed both from a desire to increase

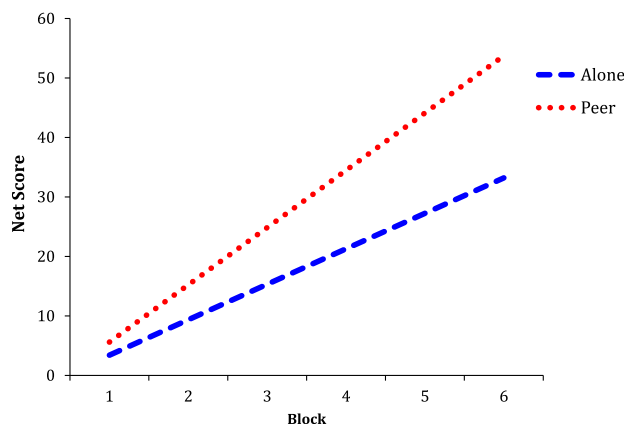


FIGURE 4 Net score across time by social condition.

TABLE 2
Unstandardized Coefficient Estimates for Models Predicting Change in Good Plays, Plays, and Net Score as a Function of Social Condition

	<i>Good Plays</i>		<i>Bad Plays</i>		<i>Net Score</i>	
	β	SE	β	SE	β	SE
Intercept (Block 6)	71.06***	6.37	53.28***	3.71	33.21***	4.49
Peer condition	8.72**	3.36	-10.80*	5.21	20.53***	6.29
Good plays on BL1	0.19*	0.08	—	—	—	—
Rate of change	5.74***	1.58	-3.97***	0.88	5.96***	1.00
Peer condition	1.69*	2.91	-3.39**	1.23	3.67**	1.39
Good plays on BL1	-0.07***	0.02	—	—	—	—
Variance components						
In intercept	234.49***	37.65	553.70***	97.09	841.37***	141.74
In rate of change	7.91**	2.75	25.74***	5.67	33.54***	7.12
Covariance	37.31***	8.56	110.86***	22.01	158.25***	29.91
Model fit statistics						
BIC	4004.50		5302.539		5540.58	
Chi-square (<i>df</i>)	41.51*** (16)		38.10** (20)		42.19** (20)	
RMSEA (90% CI)	0.13** (0.08, 0.17)		0.10 (0.05, 0.14)		0.11* (0.06, 0.15)	
CFI	0.93		0.88		0.88	
R ² intercept	0.15		0.05		0.11	
R ² rate of change	0.23		0.10		0.09	

Note. BL1 = Block 1; BIC = Bayesian information criterion; RMSEA = root mean square error of approximation; CI = confidence interval; CFI = comparative fit index. *N* = 101.

p* < .05; *p* < .01; ****p* < .001.

the salience of the peer context and to better mimic experiences in the real world, where adolescents' choices in groups often affect the welfare of their peers (e.g., when driving with passengers). We cannot rule out the possibility that the presence of peers increased late adolescents' rate of learning in the present study simply because their choices affected the amount of money that both they and their observers would earn—that is, adolescents' learning was faster in the group context because the stakes were in fact higher. (We note, however, that studies of adolescents in group settings using rodent models have found that peers have a greater influence on the behavior of juvenile than adult animals (Spear, 2009).) This may have motivated participants in peer groups to be more sensitive to both negative as well as positive cues in the IGT. Future studies using this paradigm might vary the extent to which participants' performance affects their observers' compensation in order to examine this issue further.

One limitation of the present study is that results are based on males and may not be generalizable to females, especially in light of evidence suggesting that males may be relatively more susceptible to peer influence (Gardner & Steinberg, 2005; Steinberg & Monahan, 2007; Sumter, Bokhorst, Steinberg, & Westenberg, 2009). Another limitation of our findings is that they are based on older adolescents,

between 18 and 22 years old. It is possible that the presence of peers would evoke different patterns of outcome sensitivity, and overall IGT performance, at different ages, although previous studies have found an even stronger peer effect on risk taking in middle adolescence (e.g., Gardner & Steinberg, 2005). Lastly, relative to national race estimates in the United States, our study sample included a high percentage of Asian Americans and low percentage of Hispanics. This demographic profile is likely because the majority of our sample were college students, and U.S. college enrollment rates are highest for Asians and lowest for Hispanics. Thus, our findings may only be generalizable to college students (who comprise approximately two-thirds of all late adolescents in the United States).

Identifying the mechanisms through which peer presence heightens late adolescents' sensitivity to feedback is beyond the scope of this study, and a limitation that should be the subject of future work in this area. One possibility consistent with our results is that the presence of peers may enhance late adolescents' ability to learn from both rewarding and punishing events in a way that shifts behavior toward the most desirable long-term outcome. One way to interpret these findings is through an evolutionary lens; it would be adaptive for individuals to be as responsive to threatening events as they are to

rewarding ones in order to increase their chances of survival. An important implication of this study is that behavior in peer groups that we and others have interpreted as reflecting a peer effect on reward sensitivity may be more properly characterized as an effect on "outcome sensitivity." Although late adolescents may engage in relatively more risky behavior when they are with their peers, they also may learn more about the environment in group settings than when they are alone. In this regard, our findings suggest that spending time with peers during adolescence may be a double-edged sword, increasing the odds that adolescents will behave recklessly, but also that they will learn from the consequences of their actions.

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Adolescents in Peer Groups Make More Prudent Decisions When a Slightly Older Adult Is Present

Karol Silva¹, Jason Chein¹, and Laurence Steinberg^{1,2}

¹Department of Psychology, Temple University, and ²Center for Social and Humanities Research, King Abdulaziz University

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Abstract

Adolescents make more reckless decisions when with peers than when alone, which poses a challenge for organizations that place adolescents in situations in which risky and myopic decision making is problematic. We asked whether the effect of peers on adolescents' decision making is mitigated by the presence of a slightly older adult. We examined whether target subjects' risk taking was greater when they were in groups of 4 late-adolescent males (ages 18–22) than when they were in groups that mixed 3 late-adolescent males with 1 slightly older adult (age 25–30); risk taking in both of these conditions was compared with that of adolescents tested alone. We found that adolescents took more risks and expressed stronger preference for immediate rewards when they were grouped with 3 same-age peers than when they were alone. When 1 adolescent was replaced by someone slightly older, however, adolescents' decision making and reward processing resembled that seen when adolescents were tested alone. Adding a young adult to a work team of adolescents may improve group decision making.

Keywords

adolescent development, risk taking, decision making, judgment, intergroup dynamics

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Most forms of risky behavior, including activities that jeopardize health and well-being, are more common during adolescence than before or after (Willoughby, Good, Adachi, Hamza, & Tavernier, 2013). One hallmark of adolescents' relative propensity to engage in risk taking, especially in comparison with adults, is that it often is manifested in groups (Albert, Chein, & Steinberg, 2013). For example, rates of automobile crashes are higher among teen drivers with teen passengers than among teenagers driving alone or adults driving with passengers (Ouimet et al., 2010; Simons-Morton, Lerner, & Singer, 2005), and the rate of group crimes relative to solo crimes is higher among youthful offenders than among adult criminals (Zimring & Laqueur, 2015). This group influence on adolescents' risk taking also has been demonstrated in experimental studies in which individuals of different ages have been randomly assigned to perform risk-taking tasks either alone or in the presence of real or illusory peers (e.g., Chein, Albert, O'Brien, Uckert, & Steinberg, 2011; Gardner & Steinberg, 2005; Smith, Chein,

& Steinberg, 2014). These experiments typically show that the presence of peers increases risk taking among youth (including individuals in their early 20s), but not among adults (Albert et al., 2013).

The present study investigated whether the age mix of the social audience—in particular, the presence of an older individual—affects the outcome of late adolescents' decision making when they are in groups. Studying the impact of an adult's presence on adolescents' risk taking can help clarify understanding of adolescents' susceptibility to social influences on decision making. Such research also has potentially important practical implications for the many organizations and institutions that assign individuals of different ages, including adolescents, to work together in groups. Although we specifically designed this

Corresponding Author:

Laurence Steinberg, Department of Psychology, Weiss Hall, Temple University, Philadelphia, PA 19122

E-mail: laurence.steinberg@temple.edu

study to simulate a common military practice of forming four-member fireteams during combat operations, the study also has clear relevance for establishments in the civilian workplace (e.g., restaurants and retail stores) and the community (e.g., volunteer organizations). For example, nearly one third of employees in the fast-food industry are teenagers (Schmitt & Jones, 2013), as are one sixth of individuals in the U.S. Marine Corps (U.S. Department of Defense, 2011).

Although the notion that the presence of adults discourages adolescents' risk taking may strike some readers as self-evident, virtually all of the extant research on this topic has focused on correlations between parental monitoring and teen misbehavior, and the direction of causal influence has been called into question (Stattin & Kerr, 2000). Little is known about how the presence of nonfamilial adults affects decision making in groups of adolescents. Also notably absent from the literature are studies in which the presence of adults has been experimentally manipulated to determine whether the presence of an adult leads to a reduction in risk taking (for a recent exception, however, see Telzer, Ichien, & Qu, 2015). In the present study, we investigated how the presence of peers affects decision making among late adolescents (ages 18–22) and whether the previously documented effect of peers on adolescents' risk taking can be reduced or reversed by the presence of a slightly older adult (age 25–30).

It is important to note that we were not interested in whether adolescents' decision making is affected by adults' active encouragement of safer choices. Indeed, evaluations of informational interventions designed to explicitly discourage risk taking among adolescents have cast doubt on their effectiveness (Steinberg, 2015). Rather, central to our theory is the idea that the impact of peers on adolescents' risk taking is often unconscious, and that the presence of peers increases risky behavior via the fundamental processes that adolescents engage to evaluate potential and received rewards. Specifically, evidence suggests that the peer effect on risk taking occurs because peers heighten adolescents' sensitivity to potential rewards (Chein et al., 2011; Smith, Steinberg, Strang, & Chein, 2015). This is especially true for immediately available rewards, as reflected in studies demonstrating that late adolescents' discounting of delayed rewards on temporal-discounting tasks is steeper when the adolescents are observed by peers than when they are alone (O'Brien, Albert, Chein, & Steinberg, 2011; Weigard, Chein, Albert, Smith, & Steinberg, 2014). Given the heightened importance of same-age peers during adolescence, we did not expect that the presence of an adult would have a similar effect on reward sensitivity or, as a consequence, risk taking.

We explored whether the mechanisms that influence sensitivity to immediate rewards might similarly account

for the moderating impact of an adult's presence on risky decision making. Specifically, we tested the hypotheses that (a) the presence of a somewhat older adult mitigates the peer effect on adolescents' risk taking and (b) this mitigation is explained by attenuation of the impact of peers on adolescents' preference for immediate rewards.

Method

The study is part of a broader program of research, funded by the U.S. Army, designed to inform military decisions about how best to group soldiers into combat teams. Accordingly, the sample was limited to males in late adolescence, who disproportionately make up the squads sent into battle. All procedures were approved by Temple University's institutional review board, as well as that of the U.S. Army.

Volunteers between the ages of 18 and 22 were recruited from local colleges and the general Philadelphia, Pennsylvania, community. Subjects were also recruited through the subject pool of Temple University's introductory psychology course. We compared subjects' behavior across three social-context conditions: (a) *solo*, in which subjects were tested alone; (b) *peer-group*, in which target subjects were tested while being observed by 3 same-age male peers; and (c) *adult-present*, in which target subjects were tested while being observed by 2 same-age male peers and an older male confederate (between 25 and 30 years old). The latter two conditions—each involving groups of 4 individuals—were meant to simulate the fireteams employed in the military, although they also are relevant to the composition of work teams in many employment settings in which adolescents and adults work together. All subjects (targets and observers across all conditions) were paid \$35 (or received 2.5 research credits) for their participation.

Testing was completed in two phases. In the first phase, we recruited and tested subjects in the solo and peer-group conditions. In the second phase, we recruited and tested subjects in the adult-present condition. We halted recruitment once a predetermined target of 100 subjects per experimental condition was met. This target sample size was based on the effect sizes ($d = 0.47$ and $d = 0.40$, respectively) we obtained in two prior studies of the peer effect in this age group (Gardner & Steinberg, 2005; O'Brien et al., 2011). With an expected effect size of approximately 0.40, a total sample of 100 per condition provides adequate power ($> .80$) to detect a significant effect ($p < .05$). Although there were 100 target subjects in each condition, the analyses reported here are based on data from 95 target subjects in the solo condition, 95 target subjects in the adult-present condition, and 100 target subjects in the peer-group condition. Ten

target subjects were excluded from the analyses because their data were incomplete.

Procedure

To encourage participation by peers who were familiar with one another, we asked interested subjects whether they had any friends (other males between 18 and 22) who might also be interested in participating. If a subject referred a friend to the study, our research team communicated directly with that individual to confirm his eligibility.

For each session in the first phase (the solo and peer-group conditions), 5 subjects, some of whom were friends and some of whom were strangers, were independently scheduled to participate at a set time, but none was informed that he might participate as a member of a group. When the 5 subjects arrived at the lab, 4 were randomly assigned to the peer-group condition, and 1 was randomly assigned to participate alone. Subjects in the two conditions were escorted to separate rooms and instructed about the study. In the peer-group condition, 1 subject (the target) was randomly selected to complete a test battery while the other 3 observed. After giving verbal consent, the subjects in this condition were left in the room for approximately 10 min, to provide them an opportunity to interact naturally.

The main procedural difference in the second phase of the study (the adult-present condition), was that 3, instead of 4, volunteers were scheduled for each experimental session, and the group was completed by a study confederate (age 25–30), who served as the adult observer. (As we discuss later, there were no demographic differences between subjects in this phase of the study and those in the first phase.) Twelve confederates (all of whom were graduate students) took turns participating. Prior to the sessions, each confederate was instructed to refrain from giving information about the experiment, revealing his familiarity with the paradigm or social-context manipulation, or explicitly providing advice to the subjects who completed the test battery.

When subjects in the adult-present condition arrived at the lab, all were escorted to a testing room and instructed about the study. As in the peer-group condition, 1 subject was selected to complete the test battery while the others observed, but in this case, the selection of the target subject was rigged so that the adult confederate was never selected. In addition, before the experimenter left the testing room to let the subjects and confederate interact naturally for 10 min, they were asked to introduce themselves—to share their name and their year in school (if a student). The purpose of this introduction was to implicitly indicate to the subjects that the group included an older person, who always indicated his status as a graduate student (i.e., a “higher ranking” individual).

The percentage of subjects who had at least one friend in their group was similar in the peer-group (56%) and adult-present (59%) conditions. Behavior of the target subjects—in either the peer-group or the adult-present condition—did not differ as a function of how many of their fellow group members they knew prior to the study.

Demographics. Subjects in all three conditions reported their age, race-ethnicity, and years of education. They also reported their parents' educational attainment, which was used as a proxy for socioeconomic status. Ninety-one percent of the target subjects were current college students, and their mean age was 19.74 years ($SD = 1.27$). Sixty-one percent were White, 9% were Black or African American, 20% were Asian or Pacific Islander, 6% were Latino, and 4% were of other or mixed races. The three conditions (solo, peer-group, adult-present) did not differ on any demographic variables for the target subjects (see Table 1, which also summarizes the demographic characteristics of the peers and confederates).

Risk taking. We used the Stoplight game (Steinberg et al., 2008) to measure risk-taking behavior. Stoplight is a simple computerized driving task in which subjects control the progression of a vehicle along a straight track,

Table 1. Demographic Characteristics of the Target Subjects, Peers, and Confederates

Characteristic	Solo condition	Peer-group condition		Adult-present condition		
	Targets ($n = 95$)	Targets ($n = 100$)	Peers ($n = 300$)	Targets ($n = 95$)	Peers ($n = 190$)	Confederates ($n = 12$)
Mean age (years)	19.88 (1.25)	19.79 (1.20)	19.77 (1.25)	19.59 (1.32)	19.69 (1.33)	27.17 (1.80)
Race (% White)	60	54	55	69	70	75
Education (years)	14.34 (0.87)	14.30 (0.95)	14.24 (0.99)	13.95 (1.29)	13.96 (1.33)	17.75 (0.62)
Parental education ^a	15.09 (1.99)	14.81 (2.11)	15.11 (2.09)	15.10 (2.02)	14.83 (1.97)	15.54 (2.41)

Note: Standard deviations are given in parentheses.

^aEducational attainment of the parents was used as a proxy for socioeconomic status (13 = some college education, 16 = college degree).

from the driver's point of view. A timer appears prominently on the screen. Subjects are instructed that their goal is to reach the end of the track as quickly as possible and that a traffic signal will turn yellow as they near each of 32 intersections. At each intersection, they must decide whether to stop the car (by using the space bar), and wait for the light to cycle from yellow to red to green, or go through the intersection. Subjects are informed that if they decide to brake, the car will stop safely, but they will lose time waiting for the light to cycle back to green. They are also told that if they decide to go through the intersection, the car may cross the intersection successfully, so that they will save time, or the car may crash into a crossing vehicle (an event that is accompanied by squealing tires and a loud crash, as well as the image of a shattered windshield), so that they will lose even more time than if they had decided to brake. Thus, subjects must decide whether to drive through the intersection in order to save time, but chance a collision with another vehicle that will cause them to lose time, or to stop and wait, and willingly lose a smaller amount of time. Risky decisions offered the potential payoff of experiencing no delay, but also the potentially costly consequence of a crash, which added significantly to the delay.

In short, at each intersection, the subjects could (a) stop, (b) cross successfully, or (c) crash (as a result of either failure to brake or taking too long to brake after the light turned red). Both the timing of the traffic signals and the probability of a crash in these intersections were varied so as to be unpredictable by the subjects. We computed a risk-taking score for each subject as the proportion of the 32 intersections at which the brakes were not applied (regardless of whether the subject crashed or ran the intersection successfully).

Risk taking (i.e., not braking at a yellow or red light) was encouraged by offering monetary incentives for completing the course in a timely fashion. Specifically, all target subjects (across conditions) were informed that, in addition to their baseline compensation, they could earn a \$15 bonus depending on how they performed on the task. They were told that their performance would be evaluated against a "performance threshold" that was based on how well past subjects had performed on the task, and that they would receive the bonus if they reached the threshold, which was unknown to the experimenter. In actuality, there was no performance threshold, and all subjects received the bonus regardless of their performance. This incentive manipulation was meant to force subjects to pit possible gains (i.e., saving some time by running the lights) against possible losses (i.e., losing more time if they crashed when they ran the lights). Moreover, in an attempt to reproduce some of the cohesion that is often characteristic of real-world peer groups, such as combat units in the military or projects

teams in the workplace, we informed subjects in the two group conditions that each observer's potential \$15 bonus depended on the behavior of the target subject. Therefore, the target subject had to consider how the potential gains and losses resulting from his decisions affected not only his own ultimate reward, but also that of his team members. Incentivizing subjects in this manner was meant to induce solidarity and teamwork, as these factors are important features of most real-world group settings.

Preference for immediate rewards. We used a delay-discounting task to measure preference for immediate versus delayed rewards (Steinberg et al., 2009). In the task, subjects were presented with a series of choices between a relatively small, immediate reward and a larger, delayed reward (e.g., "Would you rather have \$200 today or \$1,000 in 1 year?"). They were informed that there was no right or wrong answer and that they should simply choose which of the two (hypothetical) options they preferred. In contrast to the Stoplight game, the delay-discounting task was clearly introduced as a measure of preference, not performance. The experimenter explicitly stated that subjects' choice had no impact on their final compensation; therefore, we have no reason to believe that the bonus incentive offered for performance on the Stoplight game carried over to influence preference in the delay-discounting task. By removing this contingency, we ensured that the delay-discounting task remained a measure of reward processing outside the context of risk, so that the task simply involved a choice between a smaller reward received sooner and a larger reward received later.

The outcome of interest in delay discounting is the extent to which subjects prefer the immediate but less valuable reward over the delayed but more valuable one. In our adaptation of the task, the amount of the delayed reward was held constant at \$1,000. We varied the delay interval across six blocks (1 week, 1 month, 6 months, 1 year, 5 years, and 15 years), presented in a random order. In each block, the starting value of the immediate reward was \$200, \$500, or \$800, randomly determined for each subject. The subject was then asked to choose between the immediate reward and a delayed reward of \$1,000. If the immediate reward was preferred, the subsequent question presented an immediate reward midway between the prior one and zero (i.e., a lower figure). If the delayed reward was preferred, the subsequent question presented an immediate reward midway between the prior one and \$1,000 (i.e., a higher figure). The subject worked his way through a total of nine ascending or descending choices until his responses converged, and his preferences for the immediate and delayed rewards were equal, at a value reflecting the discounted value of the delayed reward (i.e., the subjective

value of the delayed reward if it were offered immediately; Green, Myerson, & Macaux, 2005), which is referred to as the *indifference point* (Ohmura, Takahashi, Kitamura, & Wehr, 2006). The task generated six indifference points (one for each delay interval).

For each individual, we computed the average indifference point (across all delay intervals) and the discount rate. The discount rate is an index of the degree to which an individual devalues a reward as a function of the length of delay until receipt, which we computed using the standard equation, $V = A/(1 + kD)$, where V is the subjective value of the delayed reward (i.e., the indifference point), A is the actual amount of the delayed reward, D is the delay interval, and k is the discount rate. Because, as is usually the case, the distribution of k was highly positively skewed in our sample (i.e., skew = 6.160), we employed a natural-log transformation to reduce skew to an acceptable level (-0.572). Lower indifference points and higher log-transformed discount rates indicate a greater orientation toward immediate relative to future reward. In the present sample, the correlation between the average indifference point and discount rate was significant, $r(290) = -.966, p < .001$.

As expected, given that the Stoplight and delay-discounting tasks are thought to measure different phenomena, the measures of risk taking and delay discounting (discount rate) were not significantly correlated, $r(290) = .085, p = .152$.

Statistical analysis

To estimate effects of social context on risk-taking behavior, we fitted linear regression models to the Stoplight risk-taking index using the maximum likelihood (ML) estimation method in Mplus (Version 7.0; Muthén & Muthén, 2012). Social context (solo, peer-group, or adult-present condition) was the main predictor of interest. To test behavioral differences between subjects across the social-context conditions, we created 3 dummy variables, 1 to represent each condition. Depending on the comparison of interest, 1 of these 3 dummy variables was excluded from the model to serve as the reference group. In addition, 11 dummy-coded (0, 1) covariates of no interest were included in the model to account for the confederate's identity in the adult-present condition (the confederate who participated most frequently served as the reference category, and hence was not coded in the model). For all subjects in the solo and peer-group conditions, these 11 dummy variables were coded as 0 (because no adults were present in those experimental conditions). Terms for the interactions between each of the 11 confederate dummy variables and the adult-present dummy variable were also included in the model. Including the confederate dummy variables and these interactions

allowed us not only to account for any variability due to the use of different confederates, but also to test whether any observed relations between the adult-present condition and task outcome were driven by a particular confederate.

For the delay-discounting task, we first conducted a repeated measures analysis of variance to test whether the typical delay-discounting pattern was observed across the entire sample. The indifference point at each delay interval was used as the within-subjects measure, and social context (three conditions: solo, peer-group, adult-present) was used as the between-subjects measure. To estimate effects of social context on average indifference point and on discount rate, we then fitted regression models using the ML estimation method in Mplus. As in the analysis of risk taking, 11 dummy variables corresponding to the confederate's identity, and their interactions with the adult-present dummy variable, were included in the models to control for intragroup variability within that condition and to test whether any relation between social context and behavior on the delay-discounting task was moderated by confederate's identity.

Results

Does the presence of an adult reduce peers' influence on risk-taking behavior?

Figure 1 summarizes the results for the Stoplight game. As expected, relative to solo subjects, those in the peer-group condition took significantly more risks during this game, $\beta = 0.10$, 95% confidence interval (CI) = [0.06, 0.13], $p < .001$, $d = 0.61$. In contrast, risk taking among subjects in the adult-present condition (who were observed by two same-age peers and an adult confederate) did not differ from that of solo subjects, $\beta = -0.01$, 95% CI = $[-0.07, 0.06]$, $p = .83$, $d = 0.03$. Further, subjects in the peer-group condition also took significantly more risks than those in the adult-present condition, $\beta = 0.10$, 95% CI = [0.04, 0.17], $p = .002$, $d = 0.41$. Thus, these results indicate that the presence of peers increases risk-taking behavior among late adolescents, but when a slightly older adult is introduced in a peer setting, their risk-taking behavior is similar to that observed when they are tested alone.

Does the presence of an adult reduce peers' influence on preference for immediate rewards?

Indifference point. The analysis of variance revealed a significant effect of delay interval, $F(5, 290) = 900.69$,

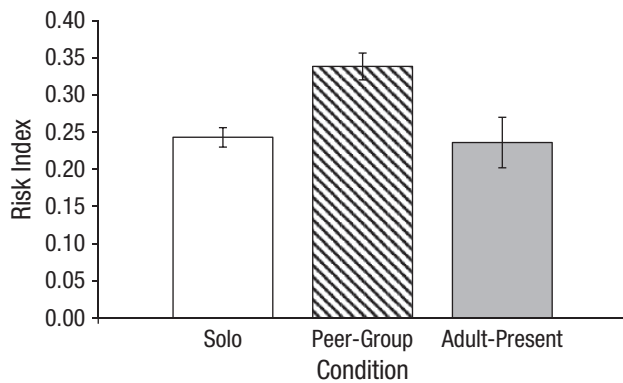


Fig. 1. Risk-taking behavior (average risk index) of the target subjects in the three social-context conditions. Error bars represent ± 1 SE.

$\eta^2 = .75$, $p < .001$. The typical delay-discounting pattern was observed across the entire sample: Indifference-point values decreased as delay intervals increased. Results for the three social-context conditions separately are summarized in Figure 2. As hypothesized, a significant effect of condition was found, $F(2, 290) = 3.14$, $\eta^2 = .02$, $p = .045$; subjects in the peer-group condition evinced a lower average indifference point ($M = \$533.81$, 95% CI = [461.28, 606.33]) than did those in the solo condition ($M = \$587.81$, 95% CI = [557.59, 618.03]) or the adult-present condition ($M = \$566.02$, 95% CI = [493.07, 638.96]). The difference in average indifference points between the solo and peer-group conditions was statistically significant, $\beta = -54.00$, 95% CI = [-96.31, -11.70], $p = .012$, $d = 0.29$, but the difference between the average indifference points in the peer-group and adult-present conditions was only marginally so, $\beta = 32.21$, 95% CI = [-10.10, 74.52], $p = .134$, $d = 0.15$. Notably, the average indifference point did not vary between the solo and adult-present conditions, $\beta = -21.79$, 95% CI = [-64.53, 20.94], $p = .317$, $d = 0.12$. Thus, these results indicate that the increase in the degree to which late adolescents discount delayed rewards when they are in the presence of peers (relative to when they are alone) is significantly reduced when there is an adult present.

Discount rate. Results for discount rates paralleled those for average indifference points (Fig. 3). Recall that higher discount rates (i.e., values closer to 0) indicate a greater orientation toward immediate relative to future reward. Subjects in the peer-group condition exhibited a higher discount rate compared with those in the solo condition, $\beta = 0.65$, 95% CI = [0.22, 1.09], $p = .003$, $d = 0.34$, whereas the discount rate did not differ between solo subjects and those in the adult-present condition, $\beta = 0.27$, 95% CI = [-0.32, 0.86], $p = .374$, $d = 0.11$. Subjects in the adult-present condition demonstrated an intermediate discounting rate that also did not differ from

the rate of those in the peer-group condition, $\beta = -0.38$, 95% CI = [-0.97, 0.20], $p = .198$, $d = 0.16$. In summary, subjects who were observed by 3 same-age peers exhibited a stronger preference for more immediate rewards than did those who performed the task alone. When an older adult replaced 1 member of the peer group, however, the presence of peers no longer intensified target subjects' tendency to find smaller immediate rewards more attractive than larger delayed ones.

Discussion

Previous studies have shown that adolescents engage in more risky decision making when they are in the presence of peers than when they are alone (Gardner & Steinberg, 2005; Smith et al., 2014), and that this effect on risky decision making may be due to the fact that peers increase adolescents' sensitivity to rewards (Chein et al., 2011; O'Brien et al., 2011; Weigard et al., 2014). The fact that adolescents take more chances and are unduly drawn to immediate rewards when they are in groups poses a potential problem for organizations that place teenagers (and young adults) in situations in which risk taking and reward-driven decision making may be less than optimal. The purpose of the present study was to examine whether the effect of peers on late adolescents' risk taking and reward sensitivity is mitigated by the presence of a slightly older individual. If so, constituting work teams so that they mix adolescents with somewhat older adults may be a useful means for improving judgment and decision making in groups of adolescents.

Our results provide evidence that such a strategy is likely to be effective. Male adolescents took more risks and expressed stronger preference for immediate rewards when they were grouped with 3 same-age, same-sex peers than when they were alone. When just 1 member of the foursome was replaced by someone in his mid- to late 20s, however, adolescents' decision making and reward processing resembled that seen when adolescents were by themselves. In other words, the presence of a slightly older individual eliminated the peer effect that heightens adolescents' risk taking and preference for immediate rewards.

We cannot be certain that the tempering effect of introducing an adult into an adolescent peer group is due specifically to the dampening impact of the adult's presence on adolescents' sensitivity to reward, but given previous studies suggesting that the peer effect on adolescents' risk taking is mediated by an increase in activity in the brain's reward centers (e.g., Chein et al., 2011), and in light of the effect of an adult's presence on reward preference in the present study, this seems to be a plausible interpretation that deserves to be tested through future neuroimaging research. Although risk

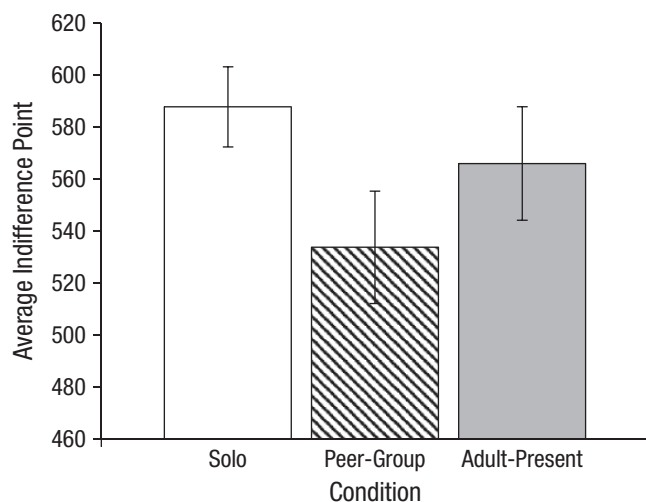


Fig. 2. Average indifference points of the target subjects in the three social-context conditions. Error bars represent ± 1 SE.

taking during the driving task was not correlated with preference for immediate rewards on the delay-discounting task, the latter task is not a measure of reward sensitivity per se, and there is evidence that temporal discounting is influenced by delay of gratification as well as reward processing (Van den Bos, Rodriguez, Schweitzer, & McClure, 2015). What we can conclude confidently is that the observed effect of the adults' presence on the adolescents' risk taking was *not* due to explicit discouragement of risky decision making by the adults, because the adults were confederates who were instructed not to advise the adolescent group members on how to behave. Even in the absence of explicit communication about the dangers of risky choices, of course, late adolescents may employ impression-management strategies in the presence of an older adult, shifting their choices in favor of what they believe reflects more mature

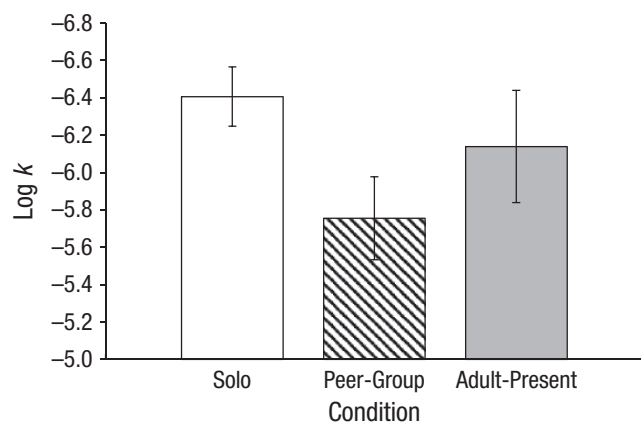


Fig. 3. Log-transformed discount rates of the target subjects in the three social-context conditions. Error bars represent ± 1 SE.

decision making. When choosing between a risky and a safe option, youth may favor the risky choice to express bravado in front of their peers, but favor the safe choice to appear more prudent in front of an adult. However, although it is easy to imagine that a youth's decision about braking at a traffic light may be intended to induce positive impressions in the eyes of his peers, it is not clear why concerns about impression management would influence subjects' preference for immediate rewards, especially when the rewards are hypothetical.

The present study has several significant limitations. One is that it does not address whether the effect that older individuals have on late adolescents' decision making is driven by particular qualities of the adults. Because age and seniority are highly correlated in the military and the workplace, we wanted to construct a scenario in which both factors would be operative. It is therefore unclear whether it was the adults' age, senior status, or demeanor that underlay their effect on the younger individuals in our study. (We attempted to minimize effects of demeanor by instructing confederates to behave in a neutral and nonintrusive fashion.) A second limitation is that our study sample included only males, and the results may not be generalizable to females. A third is that our sample consisted mainly of college students, who may not be typical of young people engaged in roles in other contexts, such as the workplace or military. However, it is likely that most individuals with the potential to carry out important decisions within a team setting are more highly educated than much of the general public, having at least a high school diploma. Finally, we did not systematically vary the extent to which group members had a prior relationship, although we did verify that this did not differ between the peer-group and adult-present conditions. Nonetheless, in most contexts, individuals who are members of work teams come to know each other over time, especially in settings like the military, where teammates live as well as work with each other. We do not know whether the results observed in this study pertain to situations in which all of a group's members are well acquainted.

Despite the fact that 18- to 22-year-olds are legal adults who frequently occupy positions of responsibility in the military and other employment settings, they are still highly susceptible to increases in risk taking in the presence of peers. This fact is consistent with growing evidence that individuals in this age range do not yet evince the mature self-regulatory capacity of individuals in their mid-20s (Steinberg, 2014). Under "cold" conditions, late adolescents often perform comparably to older individuals on various measures of cognitive control (Andrews-Hanna et al., 2011). But under conditions of emotional or social arousal, as often occur when late adolescents are with their peers, they may share certain psychological

characteristics with their somewhat younger counterparts (Cohen et al., in press; Veroude, Jolles, Croiset, & Krabbendam, 2013). Recent studies of brain development suggest that immaturity in self-regulation during this age period, including susceptibility to peer influence, may be linked to still-developing structural and functional connectivity between cortical and subcortical regions (Hwang, Velanova, & Luna, 2010; van Belle, Vink, Durston, & Zandbelt, 2014). Such evidence does not mean that individuals at this age should not be placed in positions of responsibility, but, in combination with our findings, it does suggest that under some conditions, the presence of a slightly older adult may help compensate for adolescents' neurobiological immaturity.

There is no question that late adolescents bring to work teams many desirable qualities, including spontaneity, creativity, and enthusiasm. The key for individuals who supervise people in their late teens and early 20s is to find a way to harness the passion of the young without permitting their readiness to take risks to endanger them and their teammates. If the presence of a slightly older adult coworker diminishes adolescents' myopic tendencies, it is likely that increasing contact between adolescents and adults on the job can improve decision making and deter risky behavior.

Author Contributions

L. Steinberg and J. Chein developed the study concept. K. Silva oversaw the data collection and performed the data analysis. All authors contributed to interpretation of the data. All authors contributed to writing the manuscript and approved the final version of the manuscript for submission.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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